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Computer Simulation of an Aircraft Seat and Occupant(s) in a Crash Environment - Program SOM-LA/SOM-TA User Manual

May 1991

Final Report

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16. Abstract

A three-dimensional mathematical model of a seat, occupant(s), and restraint system has been developed for use in aircraft crashworthiness analysis. Programs SOM-LA (Seat/Occupant Model - Light Aircraft) and SOM-TA (Seat/Aircraft Model - Transport Aircraft) combine a lumped parameter model of aircraft occupants with a finite element model of the seat structure. SOM-LA models a single occupant, whereas SOM-TA has the capability to model up to three passengers. The intent of these programs is to aid in evaluation of the performance of aircraft seat and restraint systems in crash environments. Because the programs have been written for use primarily by engineers concerned with the design and analysis of seats and restraint systems, an effort has been made to minimize the input that is required to describe the occupants. Characteristics of two standard occupants, one dummy and one human, are included within the program, and an option is provided to simulate other occupants by providing additional input data. The structural model includes beam elements and has a maximum capacity of approximately 450 degrees of freedom, as determined by array dimensions within the programs. The beam elements can accommodate large plastic deformations and include the capability for cross section reduction due to local instabilities. Four different cases are described, and a listing of input data is presented for each. Examples of material properties to be used as program input are included in an appendix. Details of the mathematical models and solution algorithms for the SOM-LA program were reported in DOT/FAA/CT-82/33-I (March 1983) and for the SOM-TA program in DOT/FAA/CT-86/25-I (August 1986). The program documentation, including instructions for operation, was originally presented for each program in a User Manual that was published as a second volume of each of the above reports (DOT/FAA/CT-82/33-II and DOT/FAA/CT-86/25-II). Due to program modifications, those separate manuals are now superseded by this single document.

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FOREWORD

This report was prepared by Arizona State University under Contract No. DTFA03-89-A-00004 with the Federal Aviation Administration Technical Center, where the work was monitored by Mr. Lawrence M. Neri, Mr. Thomas DeFiore, and Mr. Anthony Wilson.

This report was written by Dr. David H. Laananen of Arizona State University, Department of Mechanical and Aerospace Engineering. The computer programs documented herein were developed by Dr. Laananen at ASU and, previously, at Simula Inc. Mr. Akif O. Bolukbasi of McDonnell Douglas Helicopter Company and formerly with Simula Inc. also contributed to the software. Data for model validation have been provided by the Protection and Survival Laboratory, FAA Civil Aeromedical Institute, where the tests were conducted under the supervision of Mr. Richard F. Chandler and Mr. R. Van Gowdy.

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EXECUTIVE SUMMARY

A three-dimensional mathematical model of a seat, occupant(s), and restraint system has been developed for use in aircraft crashworthiness analysis. Programs SOM-LA (Seat/Occupant Model - Light Aircraft) and SOM-TA (Seat/Occupant Model - Transport Aircraft) combine a lumped parameter model of aircraft occupants with a finite element model of the seat structure. SOM-LA models a single occupant, whereas SOM-TA has the capability to model up to three passengers. The intent of these programs is to aid in evaluation of the performance of aircraft seats and restraint systems in crash environments. Because the programs have been written for use primarily by engineers concerned with the design and analysis of seats and restraint systems, an effort has been made to minimize the input that is required to describe the occupants. Characteristics of two standard occupants, one dummy and one human, are included within the program, and an option is provided to simulate other occupants by providing additional input data. The structural model includes beam elements and has a maximum capacity of approximately 450 degrees of freedom, as determined by array dimensions within the programs. The beam elements can accommodate large plastic deformations and include the capability for cross section reduction due to local instabilities. Four different cases are described, and a listing of input data is provided for each. These examples are (1) a simple three-passenger airline seat model with three occupants, (2) a single-occupant general aviation seat with a more complex structural configuration than that of the first example, (3) an energy-absorbing helicopter seat, and (4) a case in which two seat rows are modeled, in order to demonstrate the effects of passenger impact on the seat backs in front of them.

A line-by-line description of input data is provided in an appendix. Another appendix includes examples of input data for nonstandard occupants, several cushion materials, and a number of structural alloys. Program organization is described in detail, as are the functions of all subroutines. A complete set of output data for one of the examples is also included.

Details of the mathematical models and solution algorithms for the SOM-LA program were reported in DOT/FAA/CT-82/33-I (March 1983) and for the SOM-TA program, in DOT/FAA/CT-86/25-I (August 1986). The program documentation was originally presented as a second volume of each of the above reports (DOT/FAA/CT-82/33-II and DOT/FAA/CT-86/25-II). Due to program modifications, those separate manuals (the second volumes) are now superseded by this single document.

1.0 INTRODUCTION

Programs SOM-TA (Seat/Occupant Model - Transport Aircraft) and SOM-LA (Seat/Occupant Model - Light Aircraft) combine a lumped parameter model of aircraft occupants with a finite element model of the seat structure. SOM-LA models a single occupant, whereas SOM-TA has the capability to model up to three passengers. The intent of these programs is to aid in evaluation of the performance of aircraft seat and restraint systems in crash environments. Because the programs have been written for use primarily by engineers concerned with the design and analysis of seats and restraint systems, an effort has been made to minimize the input that is required to describe the occupants. The program allows simulation of one, two, or three passengers, of the same or different sizes. Characteristics of two standard occupants, one dummy and one human, are included within the program, and an option is provided to simulate other occupants by providing additional input data. The structural model includes beam elements and has a maximum capacity of approximately 450 degrees of freedom, as determined by array dimensions within the program. The beam elements can accommodate large plastic deformations and include the capability for cross-section reduction due to local instabilities. As an option to reduce both modeling complexity and execution costs for cases where only the restraint system or cabin configuration is of concern, or for cases where the details of the seat design may not yet be known, a rigid seat model, in which seat pan and back planes defined by input are maintained in fixed positions in the aircraft, is available. Details of the mathematical models, validation programs, and solution procedures are contained in Reference 1 for SOM-LA and Reference 2 for SOM-TA. Input instructions for the SOM-LA and SOM-TA computer programs were originally presented in References 3 and 4, respectively, which this report now replaces.

The following sections of this report present instructions necessary for the use of Programs SOM-TA and SOM-LA, and information to enable the user to operate the program most efficiently.

Sections 2.0 and 3.0 describe program input and output, respectively, including options available to the user. Section 4.0 outlines an efficient procedure for development of a mathematical model. Section 5.1 then provides detailed descriptions of sample input cases. Appendix A defines all input variables, line by line. Appendix B provides examples of material properties and occupant characteristics required as input data. Appendix C describes program organization and the functions of all subroutines. Appendix D displays the complete set of output data for the example described in Section 5.1 and Appendix A.

2.0 PROGRAM INPUT DATA

Input data are read in the following six blocks:

1. Simulation and output control information
2. Cushion properties
3. Restraint system description
4. Crash conditions
5. Occupant description
6. Seat design information.

All input data, except those pertaining to the seat (Block 6), are read by subroutine INPT; the seat data are read by subroutines SEATIN, BGEOM, CABIN, and READIN.

The coordinate system that is fixed to the aircraft at the floor has the following positive directions:

X - Forward
Y - Left
Z - Upward

The basic input data deck consists of a minimum of 26 lines of data for execution of Program SOM-LA/SOM-TA with one passenger. These are described in detail in Appendix A. The basic case makes use of a rigid seat model, specified by NSEAT = 0 on Line 3. Modeling an actual seat with the finite element analysis would require a number of additional lines, beginning with Line 27. Requesting the storage of plot data on external files, unit 14 for the occupant and unit 20 for the seat, by setting NOPLT > 0 on Line 4 or NSPLT > 0 on Line 27, requires additional lines to describe the plots. Modeling nonstandard occupant(s) requires an additional 12 data lines for each occupant, after Line 22. If the seat row in front of the passenger(s) is to be modeled, six additional lines of data must be added at the end of the input deck.

The following sections of this chapter present descriptions of each of the six input data blocks, including more detailed definitions of the above options. Line by line descriptions of input data for an example are presented in Appendix A.

2.1 SIMULATION AND OUTPUT CONTROL INFORMATION

2.1.1 Systems of Units. The NUNIT parameter on Line 3 permits the user to specify either the SI or English system of units for both input and output data. English units are presented throughout the input instructions in this report and are used in the sample input cases. In the SI system of units, all lengths are specified in meters, masses in kilograms, and forces or weights in newtons.

2.1.2 Seat Options. The NSEAT parameter on Line 3 allows the user to select either a rigid seat model or a finite element seat model. The rigid seat model consists of two planes that represent the seat pan and seat back. The positions of these planes are specified by the X and Z coordinates of their intersection (a lateral line) and two angles which specify their positions relative to horizontal and vertical planes, respectively. The length of the seat pan and the height of the seat back are used to determine the limits of the surfaces within which the seat pan and back can apply forces to the occupant. Cushions, of input specified thicknesses, are included on top of the seat pan and seat back surfaces.

The type of seat (single-, double-, or triple-occupant) is specified on Line 3, along with identification of the positions that are occupied.

2.1.3 Occupant Degrees of Freedom. The NDIM parameter on Line 3 permits selection of either two- (NDIM = 2) or three-dimensional (NDIM = 3) occupant response. The three-dimensional occupant model consists of 12 rigid segments, illustrated in Figure 1, with rotational springs and dampers at the joints. Each of the torso joints possesses three rotational degrees of freedom, or, in other words, is a ball-and-socket type joint. Because of the hinge-type motion at elbow and knee joints, the position of a forearm or lower leg relative to an upper arm or thigh, respectively, is described by one additional angular coordinate. In total, this occupant model possesses 29 degrees of freedom.

An alternative occupant model, which is restricted to plane motion, is specified by NDIM = 2 on Line 3; it consists of 11 segments, as shown in Figure 2. Beam elements in the torso and neck are capable of flexural and axial deformation. Although restricted to two-dimensional response, this occupant option does permit more direct evaluation of accident severity by output of forces and moments in the spine and neck. Restraint system forces on the ellipsoidal contact surfaces are computed three-dimensionally, but only the X- and Z-components are used. Therefore, the plane-motion model should be reserved for cases in which both the impact conditions and the restraint system are symmetrical with respect to the X-Z plane.

2.1.4 Output Control Data. Ten blocks of program output can be selected on Line 4. The data include time histories of the following variables, which are stored during solution at predetermined print intervals:

1. Occupant segment positions (X, Y, Z, pitch and roll)*
2. Occupant segment velocities (X, Y, and Z)
3. Occupant segment accelerations (x, y, z, and resultants)*
4. Restraint system loads
5. Cushion loads
6. Aircraft displacement, velocity, and acceleration
7. Injury criteria, including spinal forces and moments
8. Details of contact between the occupants and the seat or interior surfaces in front of them
9. Seat structure nodal displacements and forces
10. Seat structure element stresses.

*Upper case X, Y, Z refer to inertial or aircraft-fixed coordinate system; lower case x, y, z refer to segment fixed coordinates.

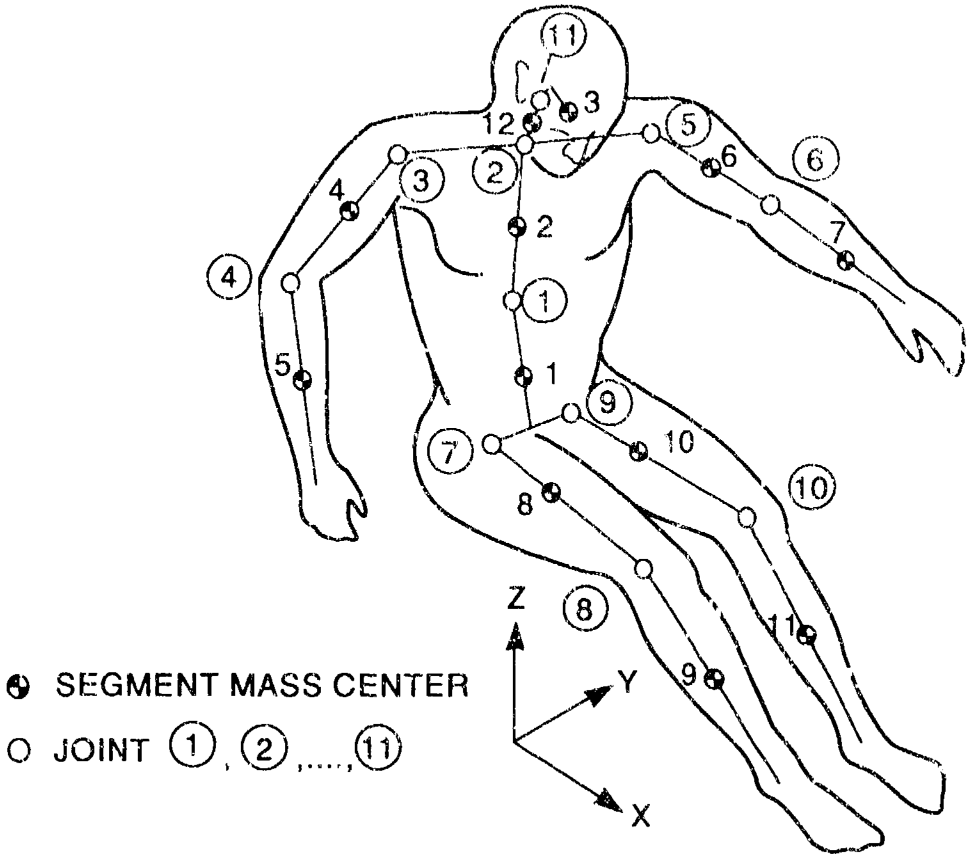


Figure 1. Twelve-segment (general three-dimensional) occupant model.

Printer plots are provided for occupant segment accelerations, restraint system loads, and cushion loads. The option of two different filters is also provided for the occupant segment accelerations and cushion loads. The particular occupant for which output data are displayed is specified in Line 4.

If plots are requested for the occupant and/or seat on Line 4, then additional lines must be included to specify plot times (up to eight) and viewing angles. As explained in the line-by-line input data descriptions, if plots are requested, the job control language must define external files 14 and 20 to be saved for postprocessing.

Program output data are described further in Chapter 3.

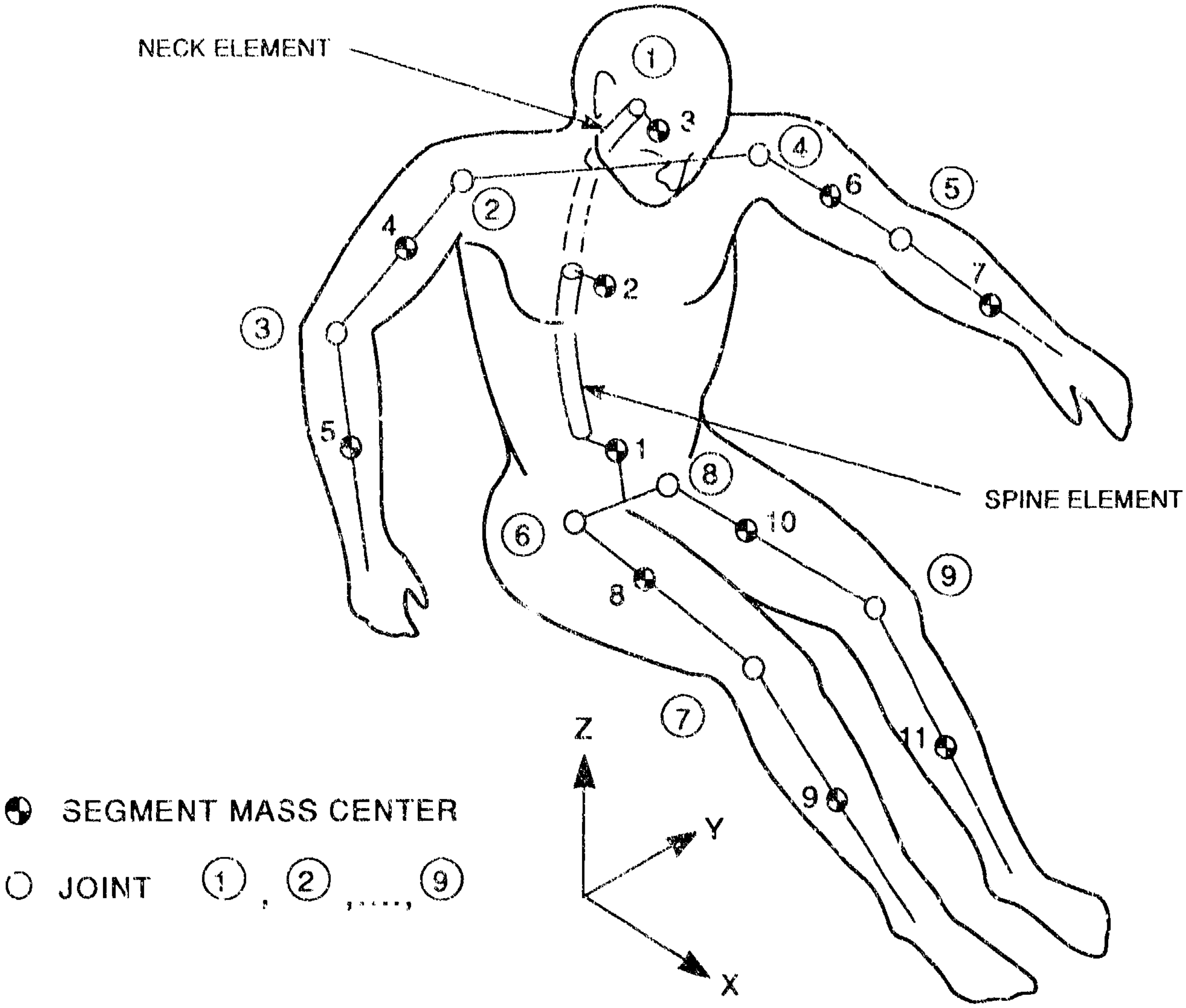


Figure 2. Eleven-segment (plane-motion) occupant model.

2.1.5 Solution Control Data. The occupant model utilizes an Adams-Moulton predictor-corrector solution procedure with a variable step size. Data on Line 5 control the step size and error bounds for the solution, as well as the duration of the simulation.

2.2 SECONDARY IMPACT/SEAT BACK CONTACT

If contact between the passengers and the seat in front of them is to be simulated by SOM-TA, the eight plane surfaces illustrated in Figure 3 must be defined by input of locations and dimensions of the seat back, tray table, and arm rests and of force deflection functions for these surfaces. During execution of the program, the distance between each of these surfaces and the 26 body contact ellipsoids is calculated. A distance less than zero indicates penetration of a surface; a contact force is computed from this penetration and applied at the appropriate points on the body and the seat.

Actual transport aircraft seats have backs that are hinged to rotate forward if pushed from behind The SOM-TA program permits the seat back to rotate forward about a transverse hinge axis at the base of the back. Should an occupant strike any of the seat back surfaces, the moment of the impact force with respect to the hinge axis is computed as the product of the normal component of the force multiplied by the distance from the axis to the contact point. The applied moment is compared with the resisting moment, and, if the net moment is greater than zero, seat back angular acceleration α is calculated according to

$$\Sigma M = M_{app} - M_{res} = I_Y \alpha \qquad (1)$$

where,

	M_{app}	=	the moment applied to the seat back by the occupant,
	M_{res}	=	the resisting moment of the seat back, and
	I_Y	=	the moment of inertia of the seat back about a transverse (Y-) axis at the hinge point.

The resisting moment M_{res} depends on the current angular displacement of the seat back from its initial position and is calculated by interpolation in a table of input moments and displacements which produce the function shown in Figure 4. Loading along the initial slope up to point 2 is elastic, so that if a slight "bump" were to occur, causing an angular displacement less than DDBO(2), the seat back would return to its initial position after removal of the load. Once DDBO(2) has been exceeded, the resisting moment remains constant at the "breakover" moment FFBO(2) up to a displacement DDBO(3). Beyond DDBO(3), the resisting moment increases rapidly, simulating a mechanical stop.

Use of the seat back contact features is specified by input of IOUT(4) > 0 on Line 4. Six additional input lines are then required following Line 26. The input format is described in Appendix A.3.

2.3 CUSHION PROPERTIES

Seat cushion forces applied to the occupant model are calculated from cushion deflections based on an exponential relationship:

$$F = C(e^{B\delta} - 1) \qquad (2)$$

Lines 8 through 10 require input of the C and B coefficients for this equation, along with damping coefficients and thicknesses. The force-deflection relationship for the seat cushion also includes compliance of the occupant buttocks. Therefore, the relationship for an occupant sitting directly on a hard seat pan would be the force-deflection curve for the occupant buttocks. Several sample force-deflection curves with their appropriate coefficients are provided in Appendix B.

2.4 RESTRAINT SYSTEM DESCRIPTION

Several restraint system configurations are available in SOM-TA/SOM-LA: lap belt only, lap with diagonal shoulder belt over either shoulder, and double shoulder belt with or without a lap belt tiedown strap. As specified on Line 3, both the lap belt and shoulder harness can be attached to either the airframe or the seat.

The force deflection characteristics of the restraint system webbing are provided by input of tables of forces and strains. Properties of representative restraint webbing types are included in Appendix B.

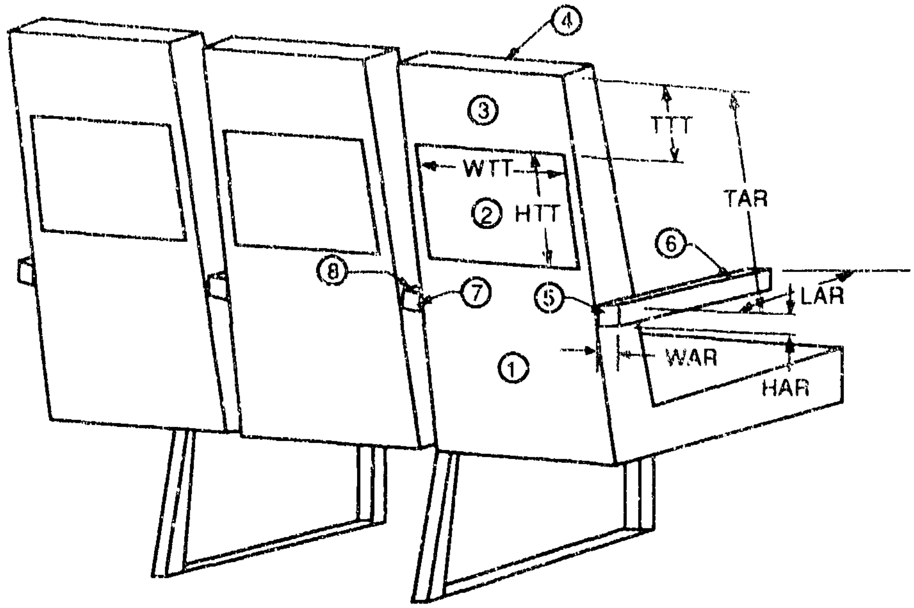


Figure 3. Seat back contact surfaces.

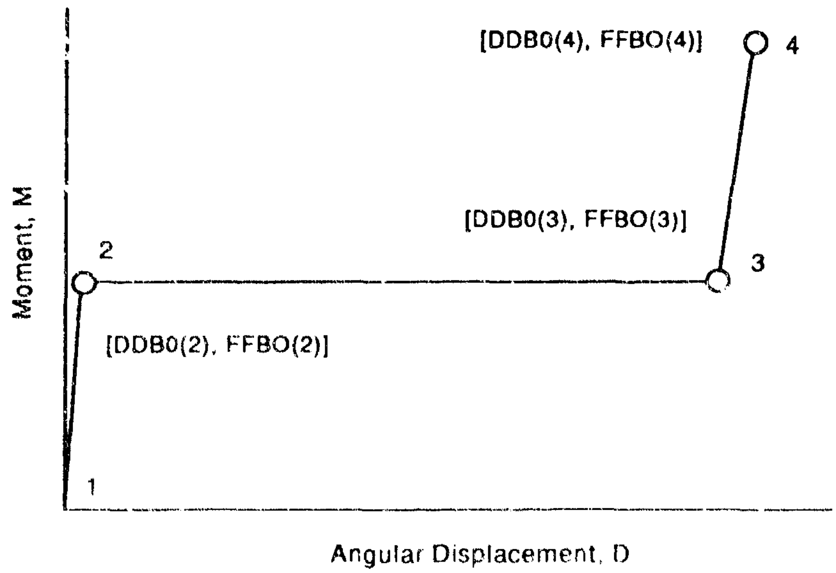


Figure 4. Seat back resisting moment function.

For a seat with a shoulder harness in which an inertia reel is mounted on the seat back and a length of inertia reel strap is passed along the seat back to a slot above the occupant shoulders, the XTRAL parameter on Line 14 defines the length of the shoulder strap behind the seat back.

2.5 IMPACT CONDITIONS

Six components of the acceleration of the aircraft coordinate system are provided on NIMPT Lines beginning with 21A: time, X, Y, Z, yaw, pitch, and roll. Acceleration components are directed in the aircraft-fixed coordinate system.

2.6 OCCUPANT DESCRIPTION

The IMAN parameter on Line 3 identifies the type of occupant being simulated. Initial positions for each passenger are specified by data on Line 22. Data for the standard occupants, a 50th-percentile U.S. male and a 50th-percentile (Part 572) anthropomorphic dummy, are included within the program. For nonstandard occupants, additional data may be provided (for each occupant) following Line 22 to define segment lengths, center of mass locations, weights, moments of inertia, contact surface radii, properties for the spine and neck, and compliances for the chest and abdomen under restraint system loading. Examples of these data are included in Appendix B.

2.7 SEAT DESIGN INFORMATION

2.7.1 Rigid Seat Option. For cases where the details of seat response are not important or not worth the greater execution costs that would be incurred by the use of the finite element structural model, a rigid seat option is provided. Plane surfaces representing the seat pan and seat back support the cushions and remain fixed in the aircraft coordinate system, except where the energy-absorbing option is used.

2.7.2 Simplified Energy-Absorbing Seat Option. If the SEATM parameter on Line 24 is greater than 0, a simplified, two-degree-of-freedom seat model is used. Intended for use in simulation of a guided energy-absorbing seat, this model permits the stroking of a rigid seat bucket in a prescribed direction. Because elastic bending of the supporting frame has been observed in testing of such seats and may influence occupant response, the second degree of freedom is added to simulate rotational elasticity of the frame.

Although the finite element analysis can provide a complete evaluation of a seat's crashworthy performance, the simple stroking seat model can prove useful in other aspects of seat design. For example, the two-degree-of-freedom model can aid in economically estimating the optimum energy absorber limit load for protection of occupants of various size, as well as in evaluating alternative restraint system configurations.

Input data for this seat model include the weight of the movable part of the seat, the direction along which it will stroke, the mass moment of inertia with respect to a lateral axis, force-deflection characteristics, and unloading slopes.

2.7.3 Finite Element Structural Analysis. The finite element seat model contained in Program SOM-LA/SOM-TA uses beam elements. The beam elements can accommodate large, plastic deformations and localized buckling of elements with hollow cross-sections. The program has a capacity for 75 nodes and 450 degrees of freedom. However, a more severe restriction is placed on the size, N, of the master stiffness matrix, given by:

$$N = MEQ + MUD * (2 * MEQ - MUD - 1)/2 \qquad (3)$$

where MUD is the length of the maximum upper diagonal of the banded stiffness matrix given by:

$$MUD = 6 * (J + 1) - 1 \tag{4}$$

MEQ equals the total number of degrees of freedom and J equals the maximum difference between node numbers across elements in the model, as illustrated in Section 4.0.

As determined by array dimensions in Program SOM-LA/SOM-TA, the quantity N is limited to 16,000.

The finite element seat model uses an unconditionally stable solution algorithm. However, stability does not necessarily imply convergence to the correct solution, and solution accuracy will depend on the size of the time step, a smaller time step yielding more accurate results. Because the seat step size is governed by that for the occupant model, reducing DMAX and DMIN on Line 5 will produce a more accurate solution. However, little improvement can be expected in reducing the seat step size below that normally required for stability in the occupant solution.

Material properties, including a three-slope approximation to the stress-strain curve, are provided on Lines 33-35, which must be repeated for each material used. (The number of materials is specified as NUMAT on Line 27.) To assist in input of material properties, summaries of input data for metals typically used in seat frames are presented in Appendix B.

Beam cross-sections can be either open or closed, but a plastic problem requires a closed cross-section to generate all the terms required by the tangent stiffness matrix. If plastic deformation of an open "I" is anticipated, the cross-section can be modeled as a closed "box" beam, which is equivalent for one bending direction, provided that the erroneous properties for other bending directions can be tolerated.

The NUMDS parameter on Line 27 specifies the number of nodes that are attached to the aircraft structure. Then, floor attachment conditions are specified on Line 43, one of which must be inserted for each of the NUMDS nodes. Element cross-sections are described by data on Lines 36 and 37, which must be repeated for each cross-section, the number of which is specified by NSECT on Line 27.

Nodal coordinates are provided on Line 38, which is repeated for each node in the model (NUMNP on Line 27) and for each beam pointer node (NCORD on Line 27). As illustrated in Appendix A, the pointer node is required to specify the initial orientation of the y-axis of a beam cross-section. A real node can be used as a pointer node, or (NCORD) additional nodes can be added solely to serve as pointers.

Element data are provided on Line 39, which must be repeated for each element (NUMEL on Line 27). Data for each element include identification of its end nodes, the pointer node that is used to orient the cross section, the cross section, the material, and end release conditions.

3.0 PROGRAM OUTPUT DATA

Output data are available from the following four sources:

1. Printer (unit 6)
2. Occupant position plots (unit 14)
3. Seat structure plots (unit 20)
4. Plots of other data (unit 26)

which are described further in the following sections.

3.1 PRINTED OUTPUT

Printed data can be selected from the ten blocks listed in Section 2.1.4. The interval at which these data are printed is selected in subroutine INPT, based on the total solution time. The interval is sized to provide a maximum of 51 lines (approximately one page) for each variable. For example, a solution time between 0.100 and 0.150 sec results in a print interval of 0.003 sec, a solution time between 0.250 and 0.300 sec, an interval of 0.006 sec, etc.

Accelerations, severity indices, vertebral forces and moments, and restraint system forces are printed in tabular and graphical formats. Other data are provided in tabular form only. Acceleration output data are computed each 0.001 sec, equivalent to a 1 KHz sampling rate. Input Line 4 provides the option of applying a Class 180 (300 Hz) or Class 60 (100 Hz) filter to the data prior to their printing.

3.2 OCCUPANT POSITION PLOTS

If specified in input Line 4, data for up to eight plots of occupant position can be stored on external file 14. The times for these plots are defined on input Line 7, along with viewing angles, which are illustrated in Figure 5. The right-side view of Figure 6 was obtained using an angle of zero degrees. The front view of Figure 7 was obtained using an angle of 90 degrees.

The IOUT(4) parameter on Line 4 can be used to draw the image of the seat in front of that being modeled. A value of 0 causes no seat to be drawn. A value of 1 or 2, respectively, produces a plot of the forward seat in its undeformed or deformed position and uses subroutine IMPACT for prediction of contact with the forward seat. The seat image is spaced according to the SPITCH parameter (Line 49).

The job control language used in executing SOM-LA/SOM-TA must define external file 14 as a permanent file to be saved. The occupant plotting program can then be executed using this same permanent file as input.

3.3 SEAT STRUCTURE PLOTS

Just as described in Section 3.2 for occupant position, data for plots of the seat structure can be requested on Line 27. As shown in Figure 8, nodes are indicated and numbered. The viewer position for the seat structure is defined by both elevation and azimuth angles, θ and ϕ, respectively, as shown in Figure 9. The view of Figure 8 was obtained with $\theta = 20$ degrees and $\phi = 45$ degrees.

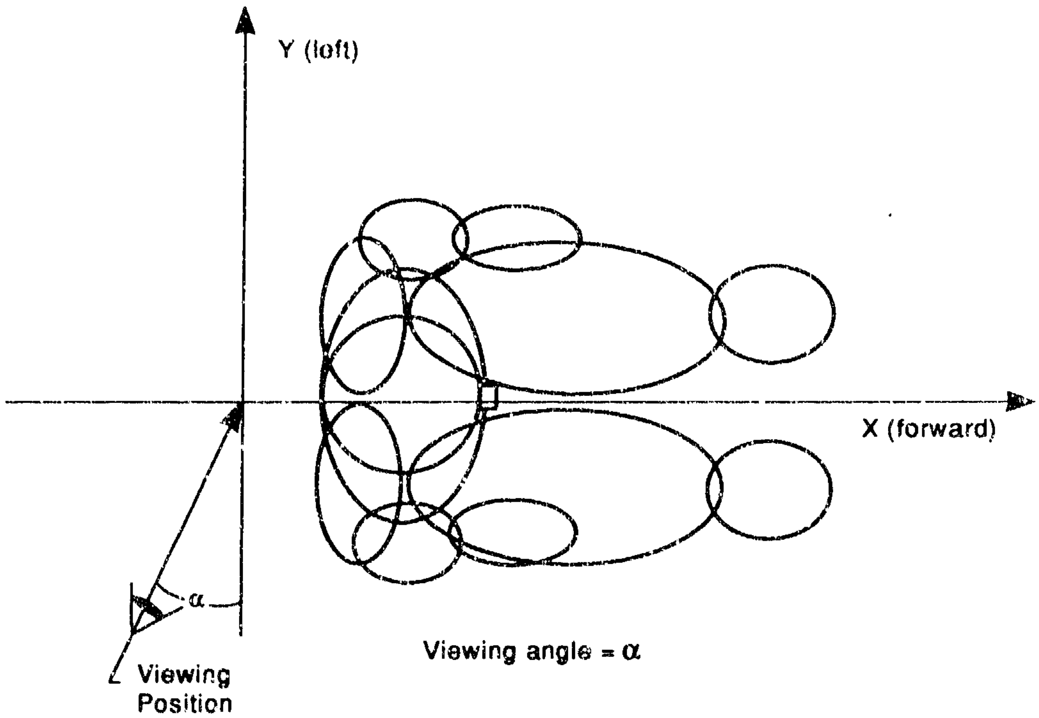


Figure 5. Definition of plot viewing angle.

The job control language must save external file 20 for subsequent use as input to the seat plotting program.

3.4 ADDITIONAL DATA FOR PLOTTING

Although the printer plots of accelerations and forces are probably satisfactory output for most purposes, there may be cases where plots with a higher level of resolution are desired. Also, pen-drawn plots may be required for use in reports. To meet these needs, 32 variables are written on external file 26 at 0.001-sec intervals. The data are written in either F10.3 or F10.5 format and are arranged as illustrated in Figure 10.

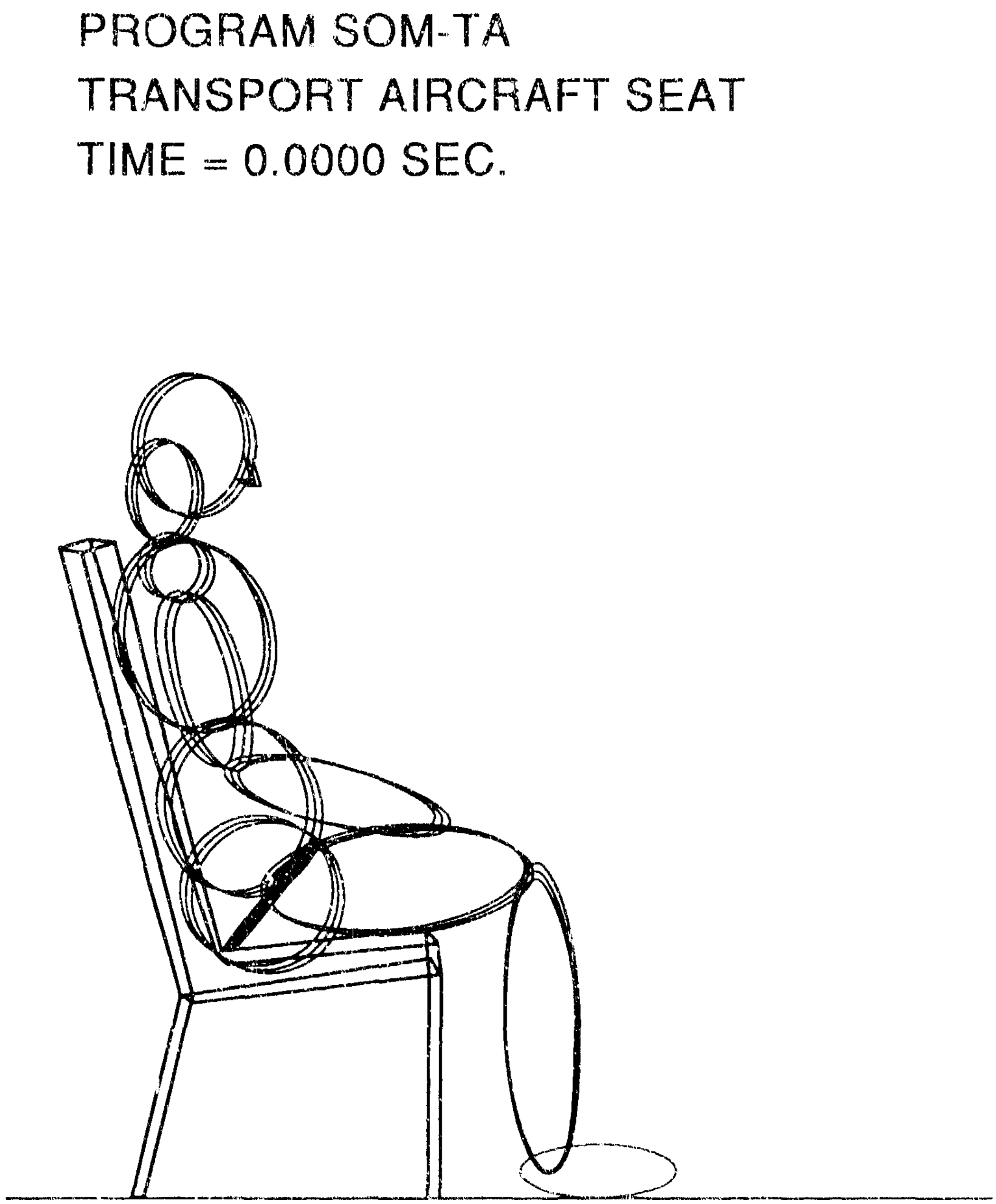


Figure 6. Sample case occupant plot (side view) at time = 0 sec.

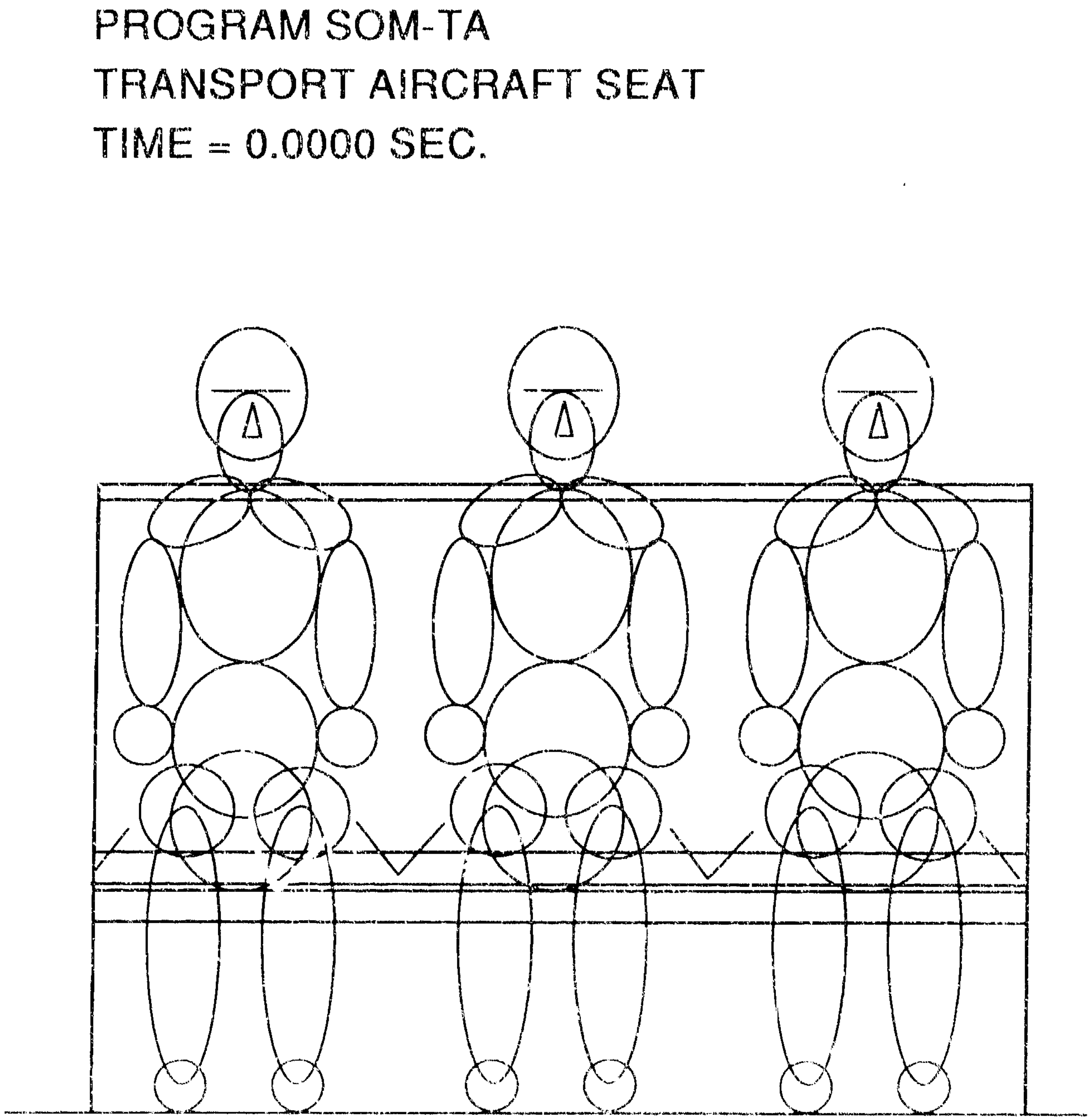


Figure 7. Sample case occupant plot (front view) at time = 0 sec.

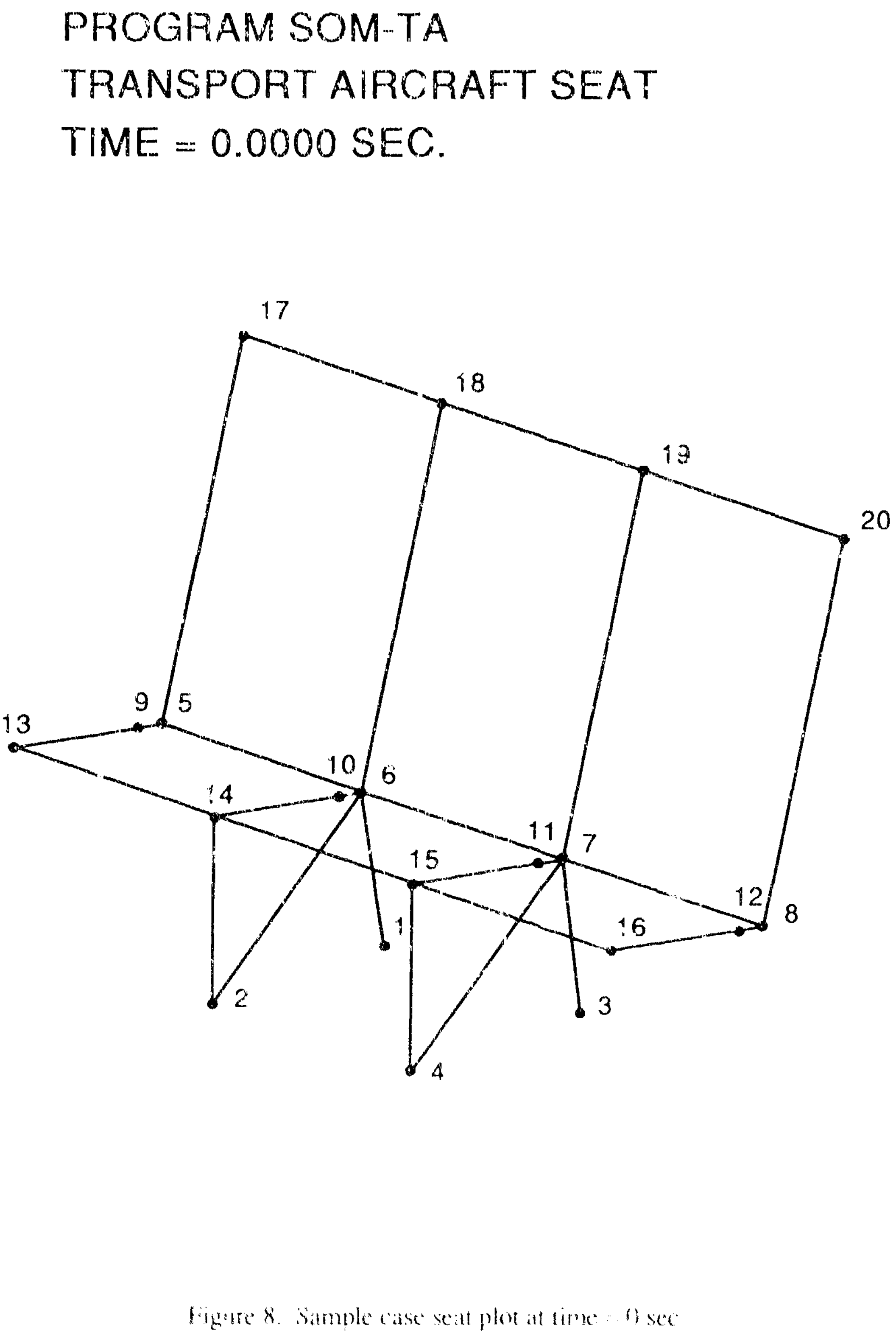
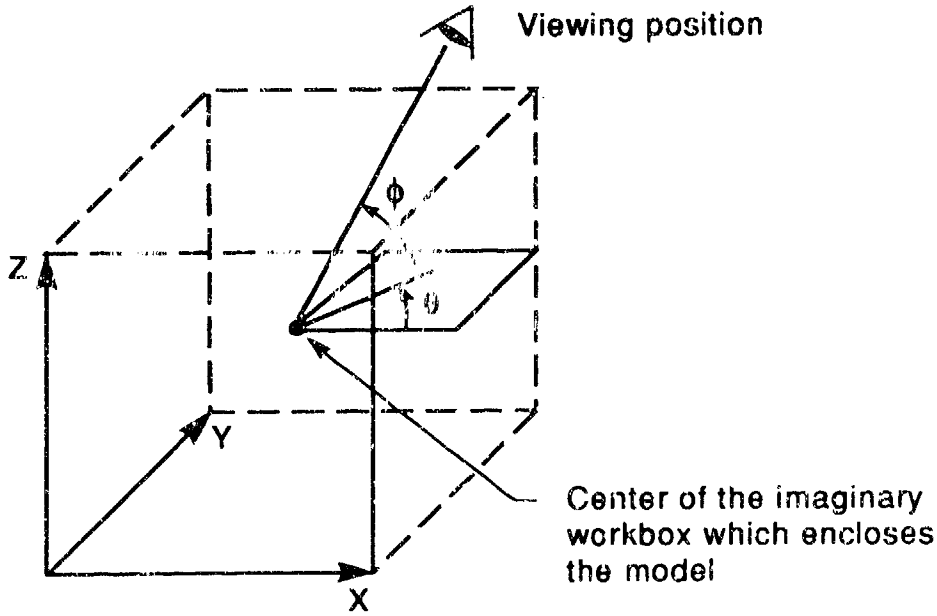


Figure 8. Sample case seat plot at time = 0 sec



θ = Azimuth angle in X-Y plane in degrees ($-180° \leq \theta \leq +180°$)
ϕ = Elevation angle in degrees ($-90° \leq \phi \leq +90°$)

Figure 6. Angular coordinates for viewing the plots.

Line	Field	Format	Variable
1	1	F10.5	Time (sec)
	2	F10.5	Aircraft X-accel (G)
	3	F10.5	Aircraft Z-accel (G)
	4	F10.5	Aircraft res. accel (G)
	5	F10.5	Aircraft res. vel. (ft/sec)
	6	F10.5	Aircraft res. displ. (in.)
	7	F10.5	Seat X-accel (G)
	8	F10.5	Seat Z-accel (G)
2	9	F10.5	Head x-accel (G)
	10	F10.5	Head z-accel (G)
	11	F10.5	Head res. accel (G)
	12	F10.5	Chest x-accel (G)
	13	F10.5	Chest z-accel (G)
	14	F10.5	Chest res. accel (G)
	15	F10.5	DRI
	16	F10.3	Seat cushion force (lb)
3	17	F10.5	Pelvis x-accel (G)
	18	F10.5	Pelvis z-accel (G)
	19	F10.5	Pelvis res. accel (G)
	20	F10.3	Lumbar axial load (lb)
	21	F10.3	Lumbar y-moment (in.-lb)
	22	F10.3	Neck axial load (lb)
	23	F10.3	Neck y-moment (in.-lb)
	24	F10.3	Back cushion force (lb)
4	25	F10.3	Right lap belt force (lb)
	26	F10.3	Left lap belt force (lb)
	27	F10.3	Right shoulder belt force (lb)
	28	F10.3	Left shoulder belt force (lb)*
	29	F10.3	Energy absorber force (lb)
	30	F10.5	Seat displacement (in.)
	31	F10.3	Footrest X-force (lb)
	32	F10.3	Footrest Z-force (lb)

*Replaced by seat angular displacement (deg) for energy absorbing seat model (with NSEAT = 0 and SEATM > 0).

Figure 10. Data format for external file 26.

4.0 INSTRUCTIONS FOR INPUT DATA PREPARATION

This chapter is intended to guide program users through an efficient process of preparing input data. The recommended procedure is summarized in Table 1. It is suggested that, if time permits, one or more of the sample cases described in detail in Chapter 5 be run initially in order to be certain that the program runs properly on a particular computer system. Storage of plot data on permanent files and subsequent access of these files using the related occupant and seat plot programs should be attempted first with the sample cases to assure that the plotting programs are compatible with the computer system and that the job control language is structured properly.

TABLE 1. SUMMARY OF INPUT DATA

1. On sketch of seat, locate aircraft floor and coordinate system.
2. Locate restraint system anchor points.
3. Locate footrest and/or heel position (at Z = 0).
4. Estimate initial position angles for occupant upper torso, head, and arms.
5. Prepare input data for and run rigid seat case for short time.
6. Plot occupant initial position and check whether it appears reasonable.
7. Add seat structure input after Line 26.
8. Run short case with complete input data.
9. Check plot of seat structure at initial time.
10. Run complete case.

The essential starting point for any simulation case is a sketch of the seat of interest, on which the aircraft floor and aircraft coordinate axes can be located. On this sketch, the restraint system anchor points, which can be fixed to either the seat or the aircraft structure, can be located, as can the position of a footrest or pedal, if applicable. The required seat design data for a rigid seat case, i.e., the locations and dimensions of the seat pan and back, can then be determined. Both the seat cushion and back cushion are assumed to be plane surfaces parallel to the seat pan and back surfaces. Using an average cushion thickness in the area of contact between the occupant and the seat, the cushion surfaces can now be added to the sketch.

Initial angular positions of the torso, head, and arm segments are required. The torso segments can be assumed parallel to, or one or two degrees forward of, the seat back. The position of the head, in a normal seated position, would range from vertical to several degrees froward of vertical, as illustrated in the Section 5.0 sample cases.

In order to be certain that the occupant initial position is reasonable for the configuration being studied, it is wise to run a short rigid seat case prior to adding the seat structure input. Starting with a small value of final time, TF, on Line 5, such as 0.010 sec, the initial position and accelerations of the occupant segments and the external forces can be checked prior to initiating a longer, perhaps more expensive case. The plot data saved on unit 14 by SOMTA can then be input to the occupant plot program and the initial position of all the occupant segments reviewed.

If the occupant's initial position, as calculated by subroutine INITIL, is geometrically impossible, the program will be stopped and informative messages printed. An example of this type of error, commonly encountered in initially running a case, is in attempting to locate the heel position beyond the reach of the legs. If the input parameters yield a geometrically feasible initial position and NOPLT > 0 on Line 4 and TOPLT = 0 on Line 7, then data for a plot of the initial position will be stored.

Once the desired initial position has been achieved for the occupant, the input data for the finite element seat structure model can be added. The NSEAT parameter on Line 3 should then be changed from 0 to 1 to signify modeling a nonrigid seat. Once again, prior to running a complete simulation, a case with a small TF should probably be run in order to check the seat structure plot at the initial time.

When it has been determined that both the occupant initial position and the seat structure configuration are as desired, a complete simulation case can be run.

5.0 SAMPLE SIMULATION CASES

This section contains descriptions of input data for sample simulation cases. A simple airline seat model with three occupants is used to illustrate program capabilities, including the preparation of input data and output data available from the program.

A complete line-by-line input data listing is discussed in Section 5.1. The contents of Appendix A show explicit input requirements for this case. Particular features of different cases are discussed in Sections 5.2 - 5.4.

5.1 SAMPLE CASE NO. 1: THREE-PASSENGER SEAT (DETAILED LISTING IN APPENDIX A)

Lines 1-2: Descriptive titles.

Line 3: NDIM = 2 for plane-motion simulation; IMAN = 1 for a standard 50th-percentile (Part 572) dummy; NSEAT = 1 for use of finite element seat model; IRSYS = 0 for lap-belt-only restraint system configuration; IBUKL = 0 (used to identify the nature of shoulder belt attachment to the lap belt if IRSYS > 0); ILBLT = 1 for lap belt attachment to seat; ISHNS = 0 (used to specify whether shoulder harness is attached to aircraft or seat if IRSYS > 0); NIMPT = 4 for input of four points in time and acceleration (Lines 21A-21D) specifying a trapezoidal pulse shape; NUNIT = 1 for English units; NOCC = 3 for three occupants to be simulated; ITYPE = 3 for a three-occupant seat type; ISEAT(1) = 1, ISEAT(2) = 1 and ISEAT(3) = 1 to specify that all seat positions are occupied.

Line 4: IOUT(1) = 1 and IOUT(2) = 1 request segment position and velocity data; IOUT(3) = 2 requests occupant segment acceleration, filtered with class 180 digital filter; IOUT(4) = 0 calls for no secondary impact simulation; IOUT(5) = 1 requests restraint system forces; IOUT(6) = 1 requests spinal loads and injury criteria; IOUT(7) = 1 requests seat external forces filtered with a class 60 digital filter; IOUT(8) = 1, IOUT(9) = 1, and IOUT(10) = 1 request seat structure deflection, support reactions, and beam loads and stresses, respectively; NOPLT = 8 for eight occupant-position plots; IPASS = 2 to specify that the output data will be stored and printed for the center occupant.

Line 5: TI = 0 and TF = 0.175 sec; DMAX and DMIN set to 0.0005 sec for fixed-time step integration; integration error bounds, EUR, and ELR, set at 10 and 0.1 percent, respectively; initial time step size, DTI, is same as fixed step size (If DMAX is not the same as DMIN, DTI should be set equal to DMIN).

Line 6: CKPTIN = 0.025 for interval (in seconds) at which restart data are to be written on unit 25.

Lines 7A-7H: Occupant plot data are to be written on unit 14 at the times specified on these eight lines. (Eight lines are required by input of NOPLT = 8 on Line 4.) Plot viewing angles (Figure 5) are all 0 deg, indicating right-side views.

Line 8: Combined seat bottom cushion and occupant buttocks force-deflection relationship of the form $F = 760\ (e^{0.58} - 1)$, as shown in Figure 11; damping coefficient of 2.40 at zero load. A cushion thickness of 1.5 in. was used.

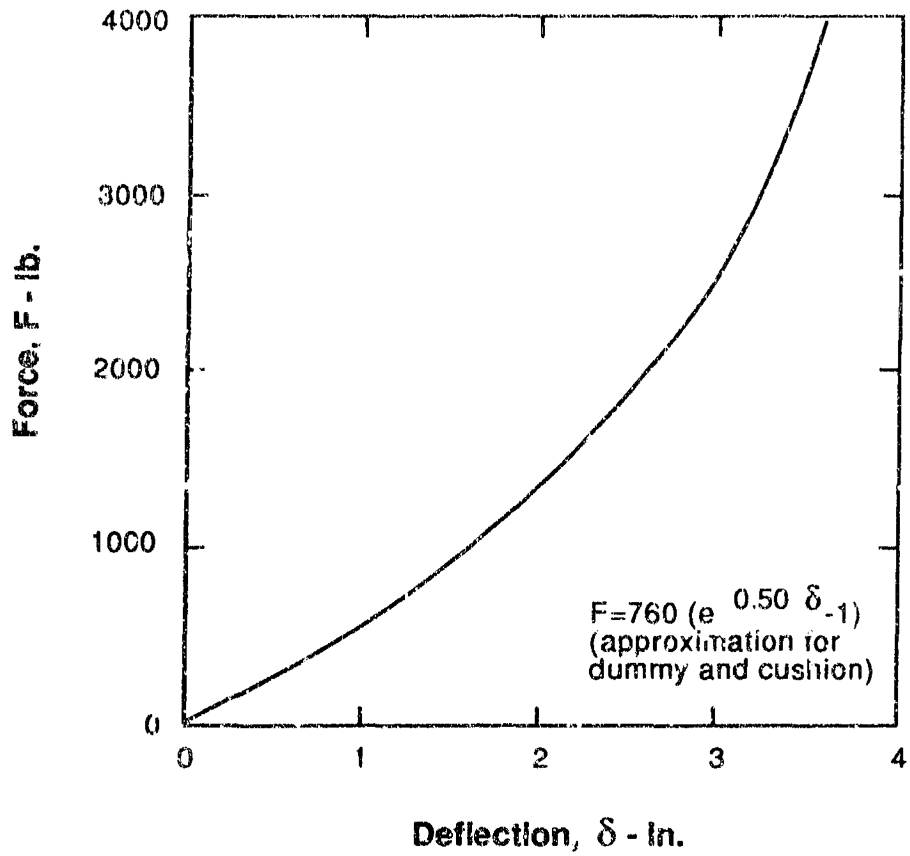


Figure 11. Exponential approximation of force-deflection characteristics for dummy and 1.5 in. thick cushion.

Line 9: Seat back cushion properties with same load-deflection curve as bottom cushion.

Line 10: Headrest cushion properties with same load-deflection curve as seat back and seat bottom cushions.

Line 11: Forces and strains for 2.0-in. nylon webbing.

Line 12A: Lap belt anchor point coordinates for passenger No. 1.

Line 12B: Lap belt anchor point coordinates for passenger No. 2.

Line 12C: Lap belt anchor point coordinates for passenger No. 3.

Line 13: Shoulder belt force-deflection properties (blank - not used in this case because IRSYS = 0 on Line 3).

Lines 14A-14C: Shoulder belt anchor point, BUKL, and XTRAL for occupants 1, 2, and 3, respectively (blank - not used in this case).

Line 15: Lap belt tiedown strap properties (blank - not used in this case).

Lines 16A-16C: Tiedown strap anchor point coordinates for occupants 1, 2, and 3 (blank - not used in this case).

Line 17: Restraint system damping coefficients and slack all zero.

Line 18: COEFFS = 0.18 and COEFFR = 0.25, friction coefficients for seat cushion and floor, respectively; XFR and ANGFR = 0.0 (used only if a footrest is to be modeled).

Line 19: Initial position of "aircraft" coordinate system in inertial system is assumed to be (0.0, 0.0, 0.0) with yaw, pitch, and roll also zero.

Line 20: Initial velocity of "aircraft" coordinate system, 30 ft/sec in X-direction.

Lines 21A-21D: Table of times and floor accelerations (X-component only, in this case). Four lines are included for the trapezoidal pulse shown in Figure 12, as required by setting NIMPT = 4 on Line 3.

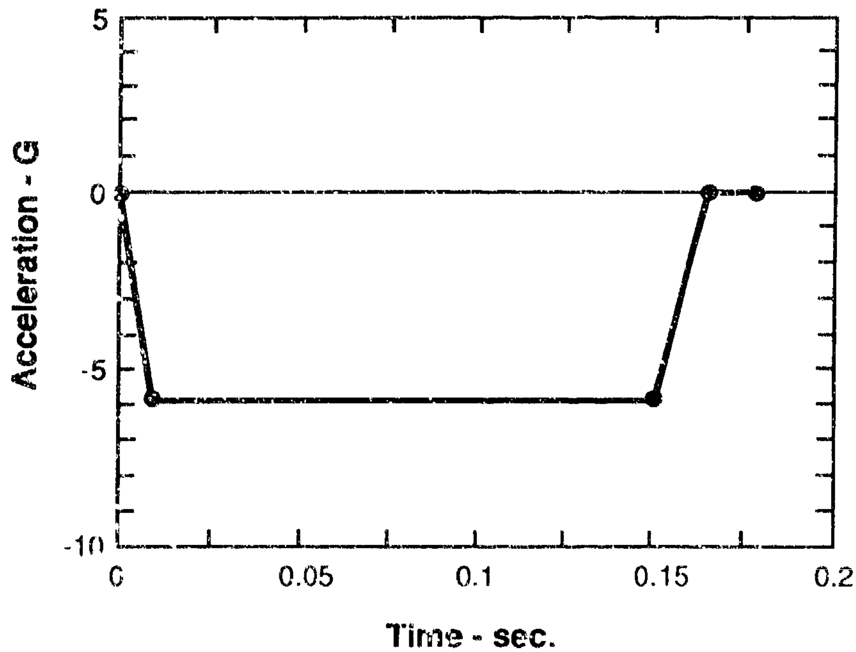


Figure 12. Approximation to sled acceleration.

Line 22-1: Initial position for passenger No. 1. GAM(1,1) and GAM(2,1) = -16 degrees; GAM(3,1) = 7 degrees; GAM(4,1) = -16 degrees for upper arms; GAM(5,1) = 60 degrees at elbow; heels at 32 in. (these coordinates are illustrated in Figure A-5); YPASS(1) = -20 in. for Y-coordinate of mid-plane for passenger No. 1.

Line 22-2: Initial position for passenger 2. Same as line 22-1 except YPASS(2) = 0 in.

Line 22-3: Initial position for passenger 3. Same as line 22-1 except YPASS(3) = 20 in.

Line 23: The coordinate system was located under the rear edge of the seat pan, so that XSEAT = 10 in.; the height of the seat pan is 12 in.; seat pan and back angles are 8 and 16 degrees, respectively. Seat pan length and width are 15.15 in. and 20 in. respectively. The height of the seat back is 39 in. (These coordinates are illustrated in Figure A-8).

Lines 24-26: Blank due to use of finite element seat model (NSEAT = 1 on Line 3).

Line 27: The finite element seat model is illustrated in Figure 13. NUMNP = 20 (real nodes); NUMEL = 27; NUMAT = 2 for two materials; NUMDS = 4 (restrained nodes on the floor); NCORD = 2 (beam pointer nodes, numbered 21 and 22); and NSECT = 2 for two beam element cross sections; NSPLT = 8 for eight seat plots.

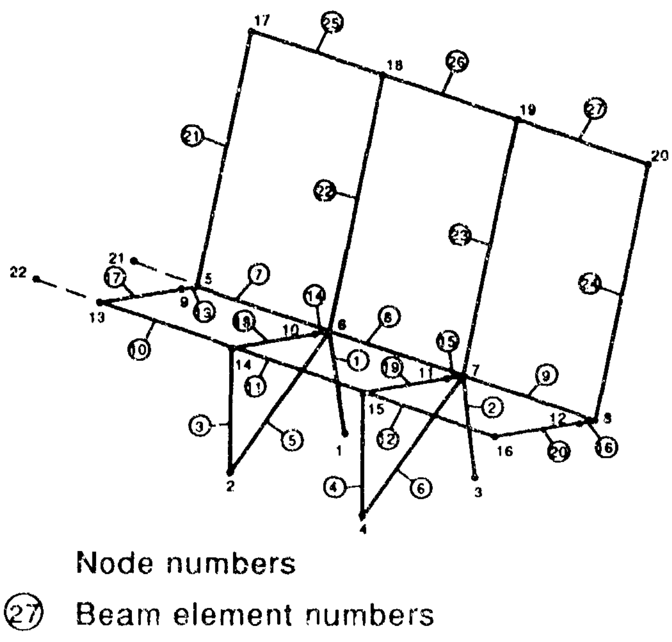


Figure 13. Sample case three-passenger seat finite element model.

Line 28: KNTRL(1) = 5 indicates that up to 5 iterations will be used at each time step. KNTRL(2) = 5 indicates that 5 load increments will be used to enforce the floor warping.

Lines 29A-29H: Seat plot data are to be written on unit 20 at the times specified on these eight lines. (Eight lines are required by input of NSPLT = 8 on Line 27.) All eight plots are to be made with an elevation angle of +20 deg and an azimuth angle of + 45 deg, i.e., viewed from left-front quarter.

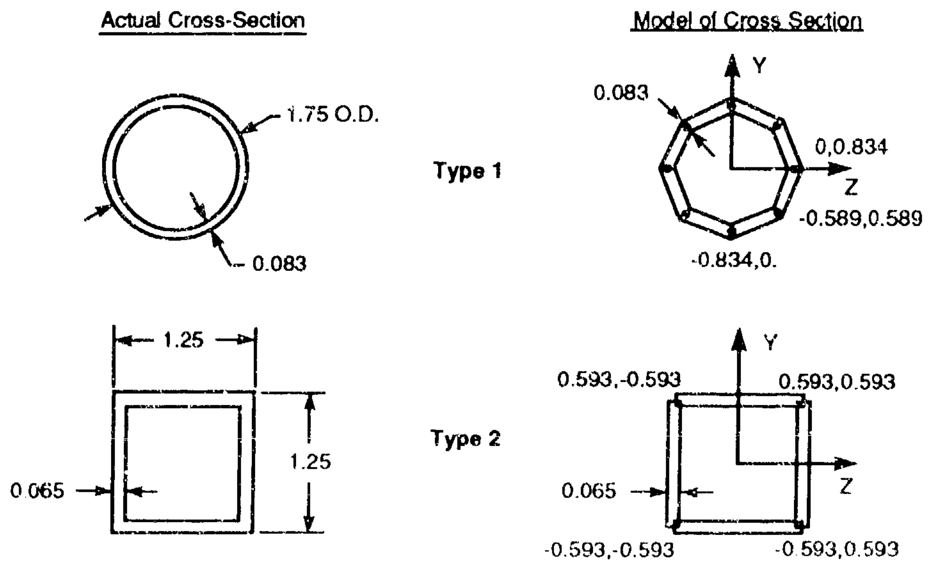
Line 30: Nodal output data are requested for nodes 1 through 20, indicated in Figure 13.

Line 31: Beam loads and stress output data are requested for elements 1 through 27, indicated on Figure 13.

Line 32: Seat structure output at intervals of 0.025 sec.

Lines 33-35: There are two groups of material properties corresponding to NUMAT = 2. Material type No. 1 is 2024-T4 aluminum; material No. 2 is 4130 steel.

Lines 36-37: There are two groups of cross-section properties (NSECT = 2), shown in Figure 14. The circular tubing cross-section, defined first, is approximated by eight segments; the square cross-section is made up of four segments. The orientation of the cross section is specified by the beam pointer node, which locates the beam y-axis (The beam coordinate system is illustrated in Figure A-13).



Note: All Dimensions in inches.

Figure 14. Element cross-section models used for seat structure beam elements

Line 38 Twenty-two lines of nodal coordinate data corresponding to 20 real nodes (NNODE = 20) and 2 pointer nodes (NUMNP = 2). Node point locations and numbers are shown in Figure 13.

Line 39: Twenty-seven lines of beam element data corresponding to NUMEL = 27. Beam element connectivity and numbers are shown in Figure 13.

Line 40: Seat pan cushion load is distributed on nodes (5, 6, 13, 14) for the first (right) occupant, (6, 7, 14, 15) for the second (middle) occupant, and (7, 8, 15, 16) for the third (left) occupant. The order in which the seat pan nodes are specified is shown in Figure A-14.

Line 41: Back cushion load is distributed on nodes (5, 6, 17, 18) for the first (right) occupant, (6, 7, 18, 19) for the second (middle) occupant, and (7, 8, 19, 20) for the third (left) occupant. The order in which the seat back nodes are specified is shown in Figure A-14.

Line 42: Lap belt loads are applied at nodes (9, 10) for the first (right) occupant, (10, 11) for the second (middle) occupant, and (11, 12) for the third (left) occupant. Three lines are used for the three passengers.

Lines 43-44: Five lines, which specify the constraint conditions at the bottom of the seat-leg elements. For nodes 1, 2, 3, and 4 all forces and only moments in Z-direction can be supported. In addition, node 2 is moved down in Z-direction by 0.5 in., corresponding to user-specified (pitch) floor warping condition.

A complete listing of the input data for this sample case is presented in Figure 15. Examples of plots generated by this case are presented as Figures 16-18.

1	2	3	4	5	6	7	8
		THREE-PASSENGER TRANSPORT AIRCRAFT SEAT					00001000
		SAMPLE CASE NO. 1					00002000
2 1	1 0	0 1	0 4	1 3	3 1	1 1	00003000
1 1	2 0	1 1	2 1	1 2	8 5	2 0	00004000
0.0	0.180	0.0005	0.0005	0.10	0.001	0.0005	00005000
0.025							00006000
0.0	0.0						00007000
0.025	0.0						00007010
0.050	0.0						00007020
0.075	0.0						00007030
0.100	0.0						00007040
0.125	0.0						00007050
0.150	0.0						00007060
0.175	0.0						00007070
760.	0.50	2.40	1.50				00008000
760.	0.50	2.40	1.50				00009000
760.	0.50	2.40	3.00				00010000
550.	1300.	2250.	0.0403	0.1048	0.1613	0.	00011000
12.5	-30.0	15.0	12.5	-10.0	15.0		00012000
12.5	-10.0	15.0	12.5	10.0	15.0		00012010
12.5	10.0	15.0	12.5	30.0	15.0		00012020
0.							00013000
0.							00014000
0.							00014010
0.							00014020
0.							00015000
0.							00016000
0.							00016010
0.							00016020
0.	0.						00017000
0.18	0.25	0.0	0.0				00018000
0.0	0.0	0.0	0.0	0.0	0.0		00019000
30.0	0.0	0.0	0.0	0.0	0.0		00020000
0.0	0.0	0.0	0.0	0.0	0.0		00021000
0.010	-6.0	0.0	0.0	0.0	0.0		00021010
0.155	-6.0	0.0	0.0	0.0	0.0		00021020
0.165	0.0	0.0	0.0	0.0	0.0		00021030
-16.0	-16.0	7.0	-16.0	60.0	32.0	-20.0	00022000
-16.0	-16.0	7.0	-16.0	60.0	32.0	0.0	00022010
-16.0	-16.0	7.0	-16.0	60.0	32.0	20.0	00022020
10.0	12.0	8.0	16.0	15.15	20.0	39.0	00023000
							00024000
							00025000
							00026000
20 27	2 4	2 2	8 0				00027000
5 5							00028000

Figure 15. Listing of input data for sample case no. 1.

1	2	3	4	5	6	7	8
0.0	45.0	20.0					00029000
0.025	45.0	20.0					00029010
0.050	45.0	20.0					00029020
0.075	45.0	20.0					00029030
0.100	45.0	20.0					00029040
0.125	45.0	20.0					00029050
0.150	45.0	20.0					00029060
0.175	45.0	20.0					00029070
1 20							00030000
1 27							00031000
0.025							00032000
12024-T4 AL							00033000
2.588E-4	10.5E6	44000.	4.9F5		62000.	0.3	00034000
58000.	62000.	0.0	0.0				00035000
24130-STEEL							00033010
7.320E-4	29.0E6	163000.	6.CE6		180000.	0.3	00034010
174000.	81000.	0.0	0.0				00035010
8 0	0.4347	0.3028	0.1514	0.1514			00036000
0.0	0.834	0.083					00037000
-0.590	0.590	0.083					00037010
-0.834	0.0	0.083					00037020
-0.590	-0.590	0.083					00037030
0.0	-0.834	0.083					00037040
0.590	-0.590	0.083					00037050
0.834	0.0	0.083					00037060
0.590	0.590	0.083					00037070
4 0	0.3081	0.1082	0.0723	0.0723			00036100
-0.593	0.593	0.065					00037100
-0.593	-0.593	0.065					00037110
0.593	-0.593	0.065					00037120
0.593	0.593	0.065					00037130
1	8.0	-10.0	0.0				00038010
2	25.0	-10.0	0.0				00038020
3	8.0	10.0	0.0				00038030
4	25.0	10.0	0.0				00038040
5	10.0	-30.0	12.0				00038050
6	10.0	-10.0	12.0				00038060
7	10.0	10.0	12.0				00038070
8	10.0	30.0	12.0				00038080
9	12.5	-30.0	12.33				00038090
10	12.5	-10.0	12.33				00038100
11	12.5	10.0	12.33				00038110
12	12.5	30.0	12.33				00038120
13	25.0	-30.0	14.108				00038130
14	25.0	-10.0	14.108				00038140
15	25.0	10.0	14.108				00038150

Figure 15 (contd). Listing of input data for sample case no. 1.

1		2			3		4		5		6		7	8
16			25.0		30.0		14.108							00038160
17			2.258		-30.0		39.0							00038170
18			2.258		-10.0		39.0							00038180
19			2.258		10.0		39.0							00038190
20			2.258		30.0		39.0							00038200
21			10.0		-40.0		12.0							00038210
22			25.0		-40.0		14.0							00038220
1	1	6			0	2	21	2	2					00039001
2	3	7			0	2	21	2	2					00039002
3	2	14			0	2	22	2	2					00039003
4	4	15			0	2	22	2	2					00039004
5	2	6			0	2	21	2	2	000	010	000	010	00039005
6	4	7			0	2	21	2	2	000	010	000	010	00039006
7	5	6			0	1	22	2	1					00039007
8	6	7			0	1	22	2	1					00039008
9	7	8			0	1	22	2	1					00039009
10	13	14			0	1	21	2	1					00039010
11	14	15			0	1	21	2	1					00039011
12	15	16			0	1	21	2	1					00039012
13	5	9			0	2	21	2	1					00039013
14	6	10			0	2	21	2	1					00039014
15	7	11			0	2	21	2	1					00039015
16	8	12			0	2	21	2	1					00039016
17	9	13			0	2	21	2	1					00039017
18	10	14			0	2	21	2	1					00039018
19	11	15			0	2	21	2	1					00039019
20	12	16			0	2	21	2	1					00039020
21	5	17			0	2	21	2	1					00039021
22	6	18			0	2	21	2	1					00039022
23	7	19			0	2	21	2	1					00039023
24	8	20			0	2	21	2	1					00039024
25	17	18			0	2	21	2	1					00039025
26	18	19			0	2	21	2	1					00039026
27	19	20			0	2	21	2	1					00039027
5	6	13	14	6	7	14	15	7	8	15	16			00040000
5	6	17	18	6	7	18	19	7	8	19	20			00041000
9	10													00042010
10	11													00042020
11	12													00042030
1111001														00043010
2112001														00043020
	[illegible]													[illegible]
[illegible]														[illegible]
[illegible]														[illegible]

Figure 15 (contd). Listing of input data for sample case no. 1

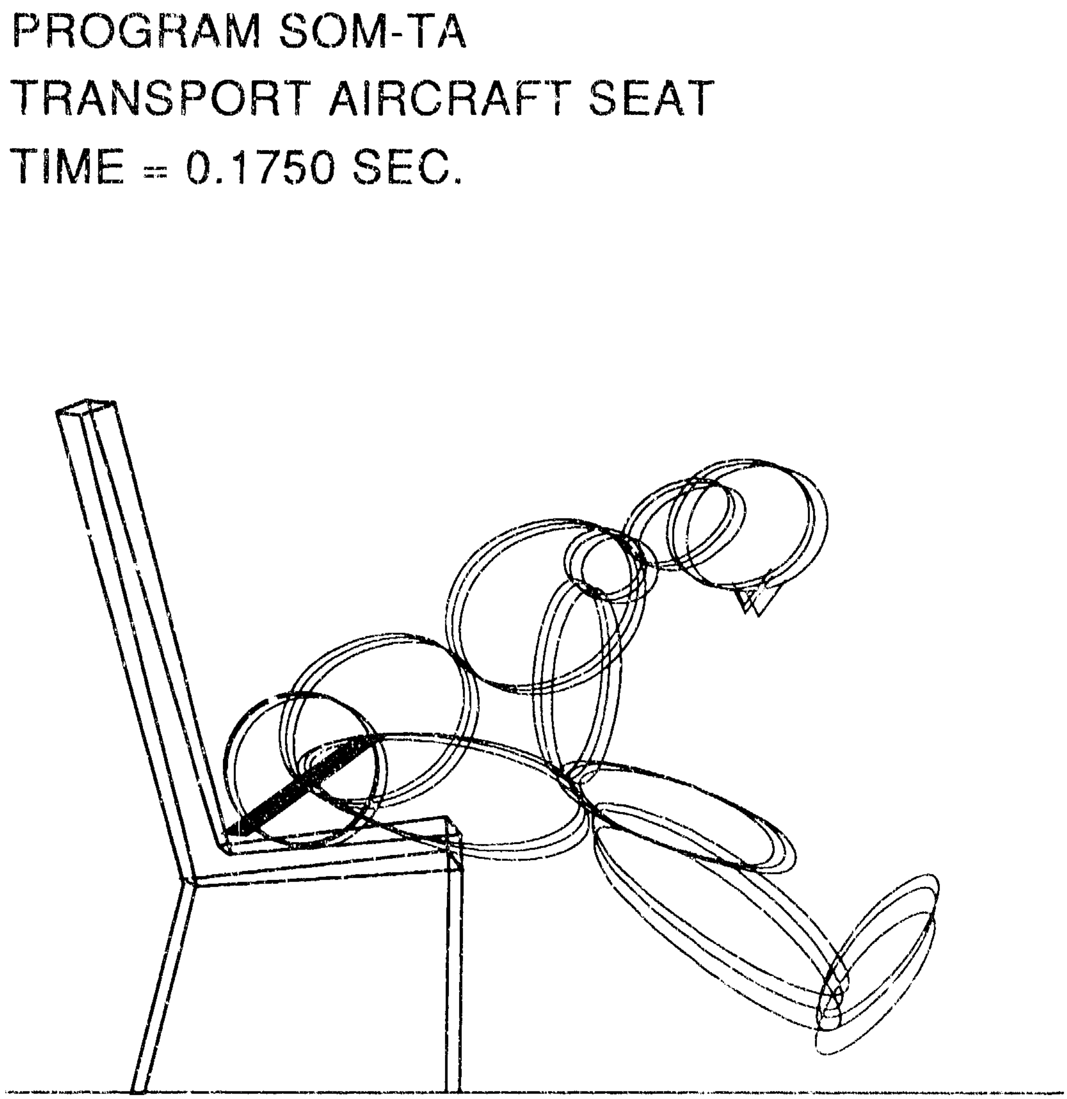


Figure 16. Sample case no. 1, occupant plot (side view) at time = 0.175 sec.

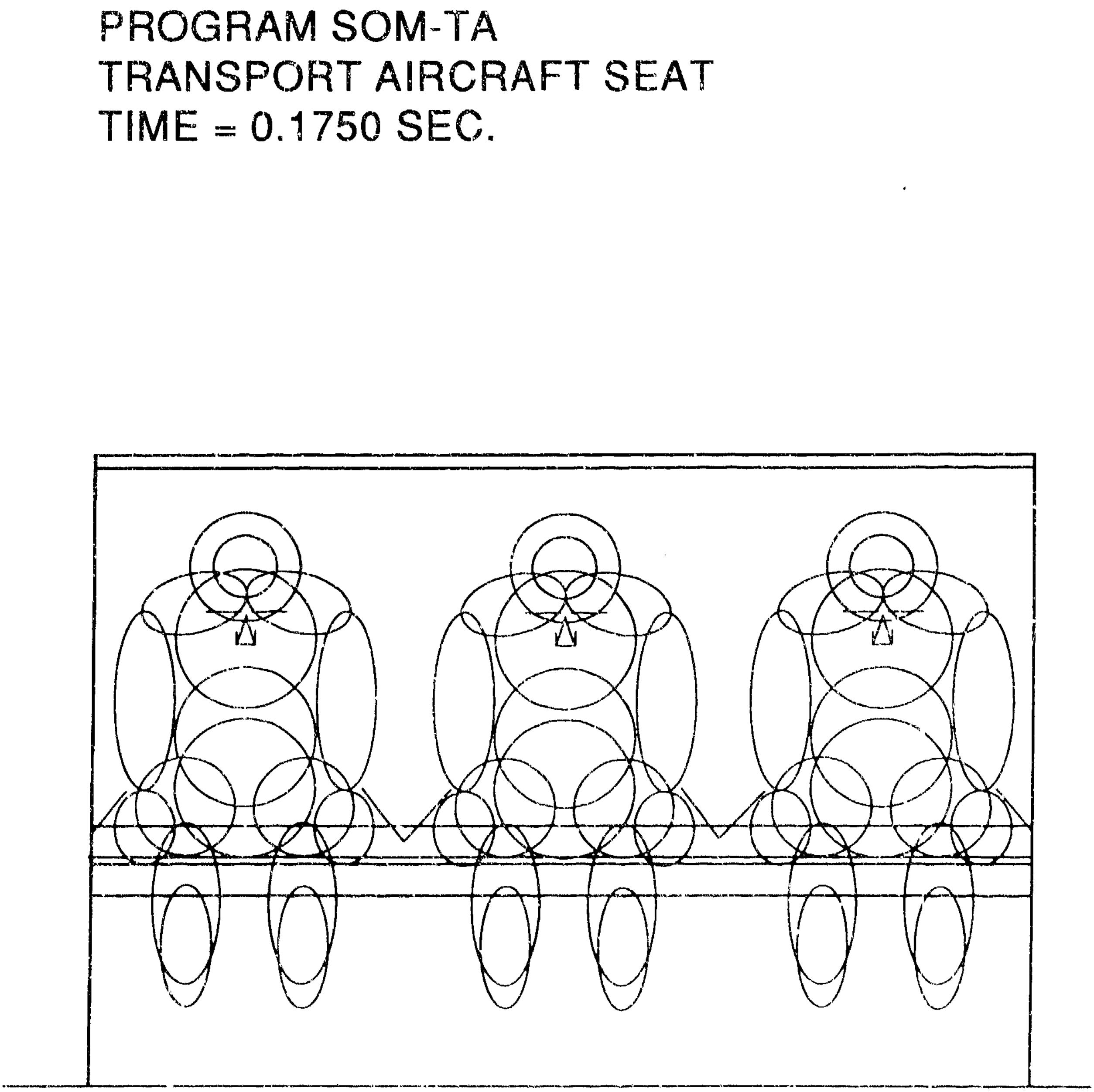


Figure 17. Sample case no. 1, occupant plot (front view) at time = 0.175 sec.

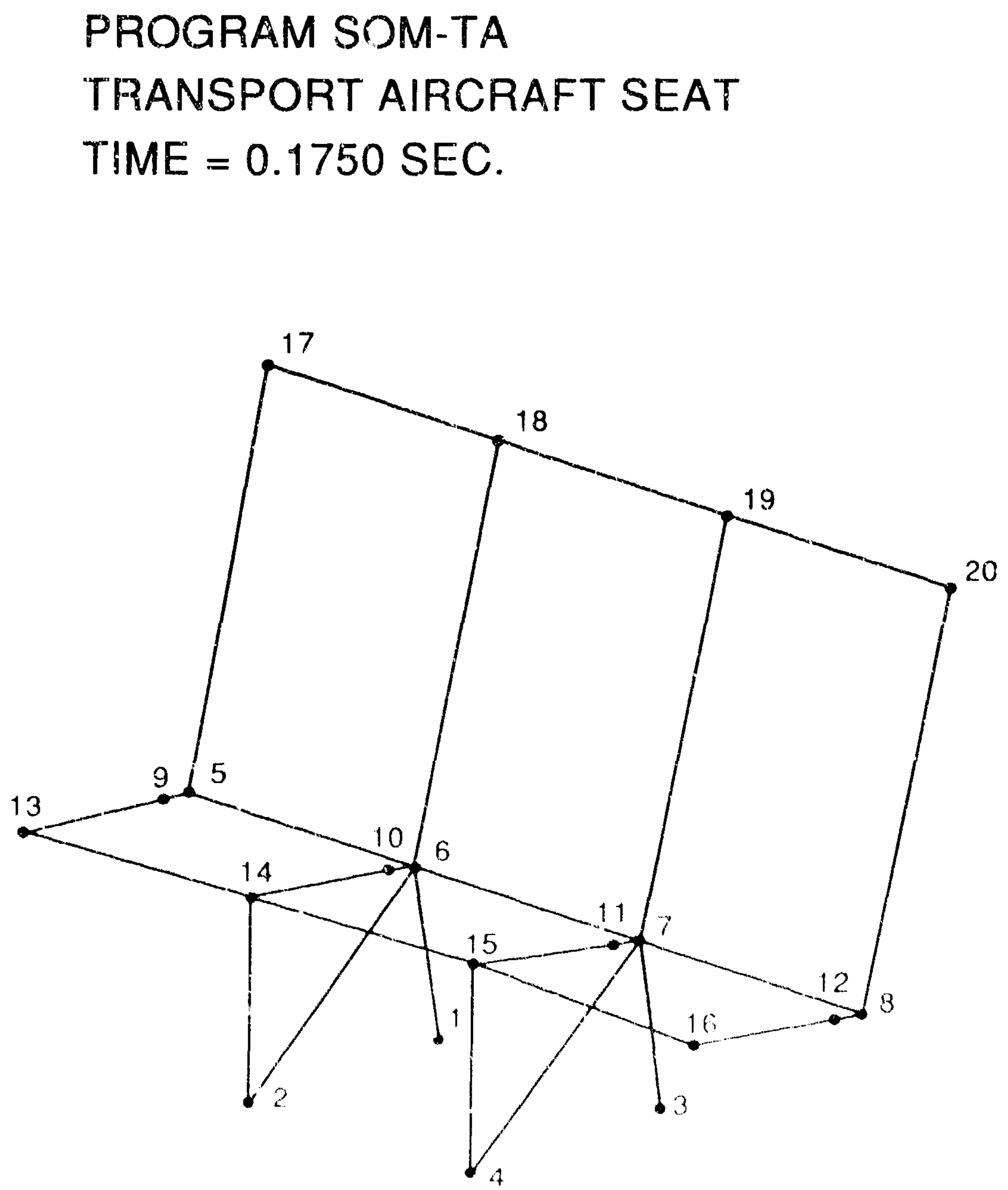


Figure 18. Sample case no. 1, seat plot at time = 0.175 sec.

5.2 SAMPLE CASE NO. 2: PRODUCTION GENERAL AVIATION SEAT

Front and side views of the production general aviation seat treated here as an example are shown in Figure 19. Note that the coordinate system has been placed on the floor at the centerline of the seat far enough aft that all points on the seat will be positive. Although this is not a requirement, such location of the coordinate system does facilitate preparation of input data.

Because of the nonsymmetric restraint system, a three-dimensional occupant simulation is requested by NDIM = 3 on Line 3. As illustrated in Figure 20, the seat structure was modeled using 28 nodes and 36 beam elements. The seat structure is fabricated of 6061-T6 aluminum alloy. The cross section of all beam elements is illustrated in Figure 21 along with the rectangular approximation utilized in the model. A listing of input data is presented as Figure 22. Because neither the lap belt nor the shoulder harness is attached to the seat, the restraint system nodes are not required. The seat has one fore-and-aft adjustment locking pin at the left-front track connection. The track connections are assumed to constrain nodes 1, 2, and 15 against translation in the Y and Z direction but leave them free in the other directions. Node 16, on the other hand, where the adjustment locking pin is located, is constrained in all directions except Z rotations. Some judgment is required as to the ability of the adjustment locking pin to resist rotations about the X or Y axes.

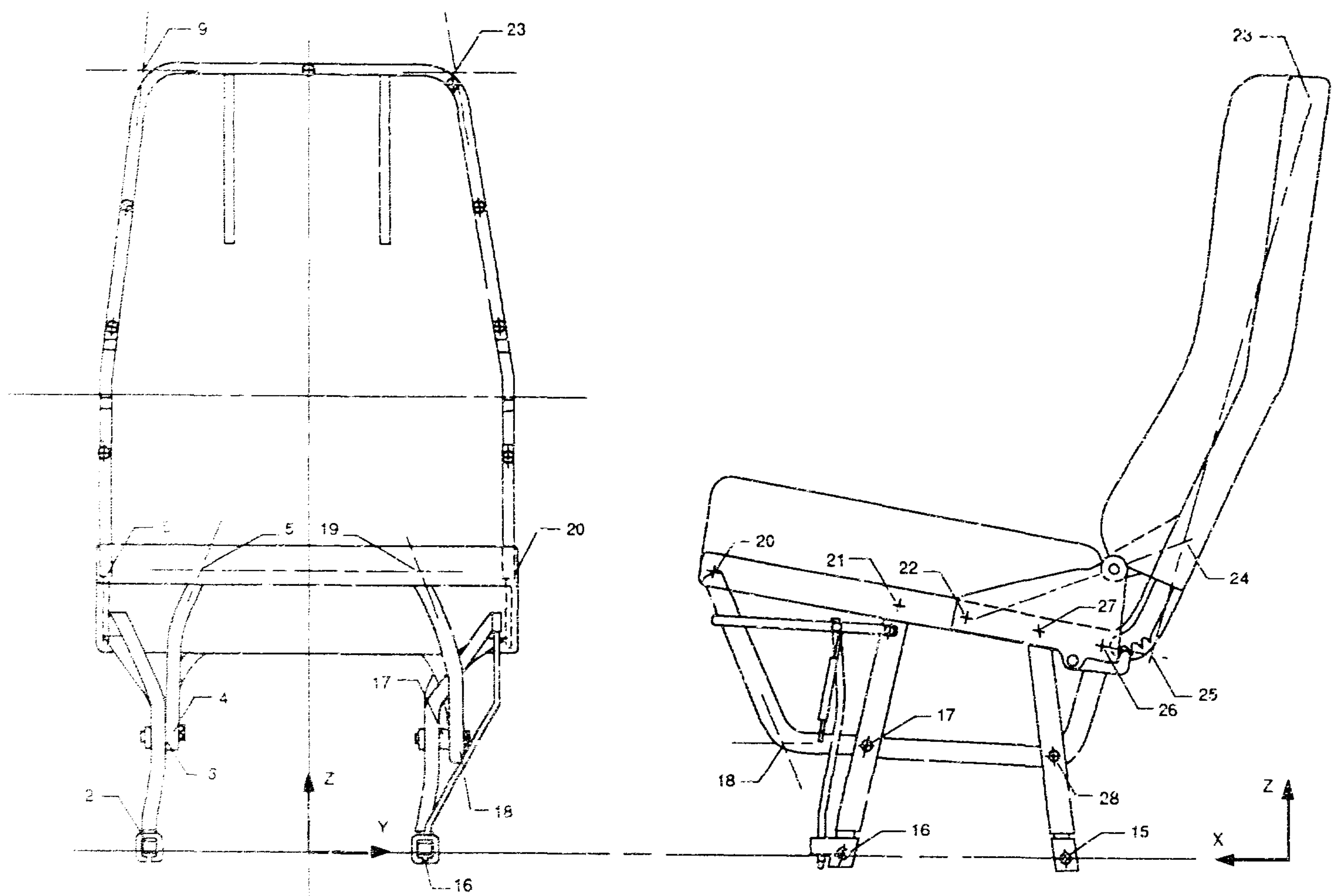


Figure 19. Production general aviation seat (with some node numbers indicated).

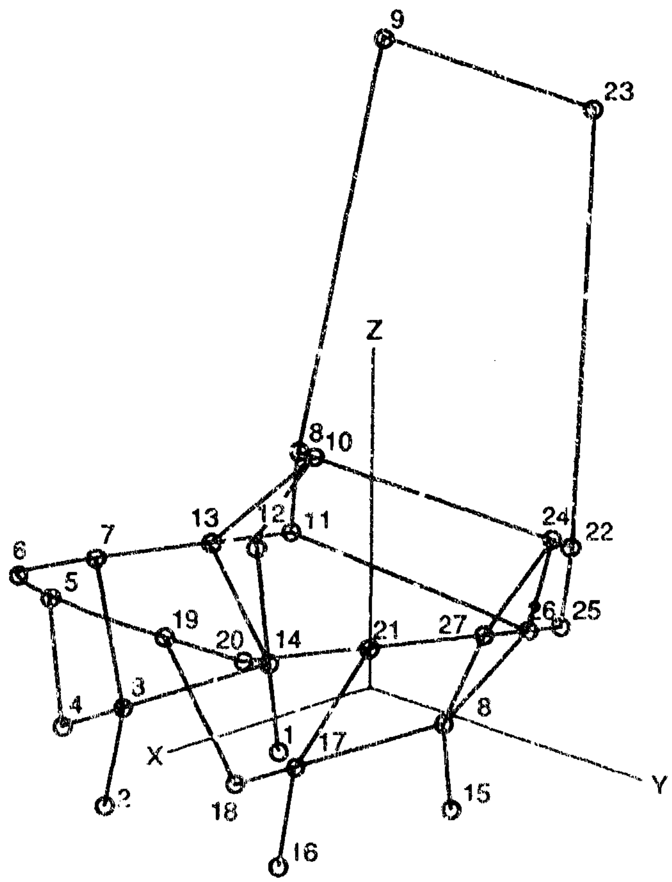
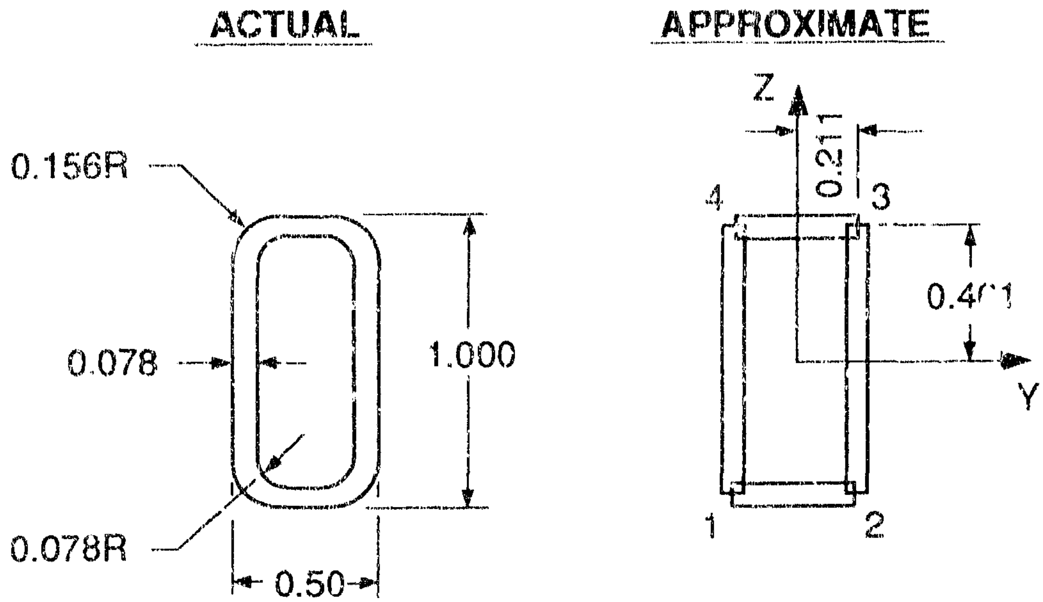


Figure 20. Finite element model of production general aviation seat.



$A = 0.1940 \text{ in.}^2$
$I_y = 0.02078 \text{ in.}^4$
$I_z = 0.00672 \text{ in.}^4$

NODE		Y	Z
1	=	-0.211	-0.461
2	=	0.211	-0.461
3	=	0.211	0.461
4	=	-0.211	0.461

Figure 21. Beam element cross section.

1	2	3	4	5	6	7	8
NONADJUSTABLE GENERAL AVIATION PILOT SEAT							00001000
SAMPLE CASE NO. 2							00002000
3 1	1 2	1 0	0 16	1 1	1 1	0 0	00003000
1 1	2 0	1 1	2 1	1 1	8 5	1	00004000
0.	0.250	0.0005	0.0005	0.1	0.001	0.0005	00005000
0.025							00006000
0.0	0.0						00007000
0.040	0.0						00007010
0.080	0.0						00007020
0.120	0.0						00007030
0.160	0.0						00007040
0.200	0.0						00007050
0.220	0.0						00007060
0.240	0.0						00007070
197.2	0.70	0.87	2.00				00008000
197.2	0.70	0.87	2.00				00009000
0.0	0.0	0.0	0.0				00010000
550.	1300.	2250.	0.0403	0.1048	0.1613		00011000
7.50	-9.50	0.50	7.50	9.50	0.50		00012000
550.	1300.	2250.	0.0403	0.1048	0.1613		00013000
-16.0	15.75	46.00	13.25	0.00			00014000
0.0							00015000
0.0							00016000
0.0	0.0	0.0	0.0				00017000
0.18	0.25	0.0	0.0				00018000
0.0	0.0	0.0	0.0	0.0	0.0		00019000
50.0	0.0	0.0	0.0	0.0	0.0		00020000
0.0	0.0						00021000
0.0092	-0.109						00021010
0.0262	-8.93						00021020
0.0330	-10.9						00021030
0.0389	-11.9						00021040
0.0420	-11.6						00021050
0.0550	-12.4						00021060
0.0716	-12.2						00021070
0.0805	-10.7						00021080
0.0933	-11.1						00021090
0.1000	-9.29						00021100
0.1463	-11.6						00021110
0.1592	9.59						00021120
0.1688	3.47						00021130
0.1750	0.952						00021140
0.2180	0.0						00021150

Figure 22. Input data listing, case no. 2

1	2	3	4	5	6	7	8
-8.4	-8.4	0.0	-30.0	60.0	37.0	0.0	00022000
4.67	7.93	9.20	8.40	15.30	15.80	29.2	00023000
							00024000
							00025000
							00026000
28 40	1 4	4 1	8				00027000
5 1							00028000
0.0	45.0	20.0					00029000
0.040	45.0	20.0					00029010
0.080	45.0	20.0					00029020
0.120	45.0	20.0					00029030
0.160	45.0	20.0					00029040
0.200	45.0	20.0					00029050
0.220	45.0	20.0					00029060
0.240	45.0	20.0					00029070
1 28							00030000
1 36							00031000
0.025							00032000
16061-T6 AL							00033000
2.588E-4	10.0E6	36000.	1.0E6		45000.	0.3	00034000
42000.	18750.	0.0	0.0				00035000
4 0	0.1940	0.03452	0.02078	0.00672			00036010
-0.211	0.461	0.078					00037010
-0.211	-0.461	0.078					00037020
0.211	-0.461	0.078					00037030
0.211	0.461	0.078					00037040
1	8.0	-5.00	0.0				00038010
2	17.9	-5.00	0.0				00038020
3	17.0	-5.00	4.16				00038030
4	20.5	-5.00	4.29				00038040
5	23.0	-3.30	10.9				00038050
6	22.1	-7.00	10.76				00038060
7	15.82	-7.90	9.75				00038070
8	4.15	-7.90	11.3				00038080
9	1.50	-6.10	29.20				00038090
10	4.15	7.00	11.30				00038100
11	4.67	-7.90	7.93				00038110
12	6.57	-7.90	8.24				00038120
13	9.22	-7.90	8.68				00038130
14	8.57	5.00	[illegible]				00038140
15	8.00	5.00	[illegible]				00038150
16	17.9	5.00	[illegible]				00038160
17	[illegible]	[illegible]	[illegible]				[illegible]

Figure 22 (contd). Input data listing, case no. 2.

	1		2	3		4		5		6		7	8
18			20.5	5.00		4.29							00038180
19			23.0	3.30		10.9							00038190
20			22.1	7.00		10.76							00038200
21			15.82	7.90		9.75							00038210
22			4.15	7.90		11.3							00038220
23			1.50	6.10		29.2							00038230
24			4.15	7.00		11.3							00038240
25			4.67	7.90		7.93							00038250
26			6.57	7.90		8.24							00038260
27			9.22	7.90		8.68							00038270
28			8.57	5.00		3.87							00038280
29			8.57	0.0		3.87							00038290
30			17.0	0.0		4.16							00038300
31			23.0	0.0		10.9							00038310
32			4.67	0.0		7.93							00038320
1	1	14		0	1	29	2	1					00039001
2	2	3		0	1	30	2	1					00039002
3	14	3		0	1	29	2	1					00039003
4	3	4		0	1	30	2	1					00039004
5	4	5		0	1	31	2	1					00039005
6	5	6		0	1	31	2	1					00039006
7	6	7		0	1	31	2	1					00039007
8	7	13		0	1	31	2	1					00039008
9	12	13		0	1	32	2	1					00039009
10	3	7		0	1	30	2	1					00039010
11	14	13		0	1	29	2	1					00039011
12	14	12		0	1	29	2	1					00039012
13	8	10		0	1	32	2	1	000	100	000	000	00039013
14	8	11		0	1	32	2	1					00039014
15	9	8		0	1	32	2	1					00039015
16	15	28		0	1	29	2	1					00039016
17	16	17		0	1	30	2	1					00039017
18	28	17		0	1	29	2	1					00039018
19	17	18		0	1	30	2	1					00039019
20	18	19		0	1	31	2	1					00039020
21	19	20		0	1	31	2	1					00039021
22	20	21		0	1	31	2	1					00039022
23	21	27		0	1	31	2	1					00039023
24	26	27		0	1	32	2	1					00039024
25	17	21		0	1	30	2	1					00039025
26	28	27		0	1	29	2	1					00039026
27	28	26		0	1	29	2	1					00039027
28	22	24		0	1	32	2	1	000	100	000	000	00039028

Figure 22 (contd). Input data listing, case no. 2.

```
          1         2         3         4         5         6         7         8
  29   22   25              0    1   32    2    1                         00039029
  30   23   22              0    1   32    2    1                         00039030
  31    5   19              0    1   32    2    1                         00039031
  32   12   26              0    1   31    2    1                         00039032
  33    9   23              0    1   32    2    1                         00039033
  34   10   24              0    1   32    2    1                         00039034
  35   12   10              0    1   32    2    1                         00039035
  36   26   24              0    1   32    2    1                         00039036
  37   11   12              0    1   32    2    1                         00039037
  38   25   26              0    1   32    2    1                         00039038
  39   10   13              0    1   32    2    1                         00039039
  40   24   27              0    1   32    2    1                         00039040
  12   26    5   19                                                       00040000
  10   24    9   23                                                       00041000
   0                                                                      00042000
  1111101                                                                 00043000
  2111101                                                                 00043010
 15111101                                                                 00043020
 16111101                                                                 00043030
```

Figure 22 (contd). Input data listing, case no. 2.

5.3 SAMPLE CASE NO. 3: ENERGY-ABSORBING HELICOPTER SEAT

A production energy-absorbing helicopter seat was tested at CAMI. The test configuration is illustrated in Figure 23. A complete listing of input data is presented as Figure 24.

Headrest properties are provided on Line 10. In addition to lap belt and shoulder belt properties and locations on Lines 11-14, the lap belt tiedown strap of the five-point restraint system is described on Lines 15 and 16. The webbing is a low-deflection polyester type, whose load-elongation properties are illustrated in Figure B-5. The five-point restraint system is indicated by IRSYS = 4 on Line 3.

As shown in Figure 23, the seat was rotated on the horizontal sled in order to simulate a near-vertical impact. The input acceleration is input in both X- and Z-components, on Lines 21A-21H. The pitch of -73 degrees is entered on Line 19.

Energy absorber data are entered on Line 25. The load-stroke characteristics for the seat are illustrated in Figure 25. The guide tubes shown in Figure 23 are oriented 4 degrees from the Z-axis, and this angle is input on Line 24, along with the movable seat weight of 60.6 lb. It is this nonzero seat weight that causes the stroking seat model to be used.

Line 24 includes the unloading slope of 4308 lb/in. and the damping coefficient of 0.55 lb-sec/in., which was determined by matching the measured energy absorber force-time history. A moment of inertia of 148 lb-in.-sec™ with respect to the aircraft coordinate system was estimated for the seat. Rotational stiffness parameters on Line 26 were estimated from static tests of the seat.

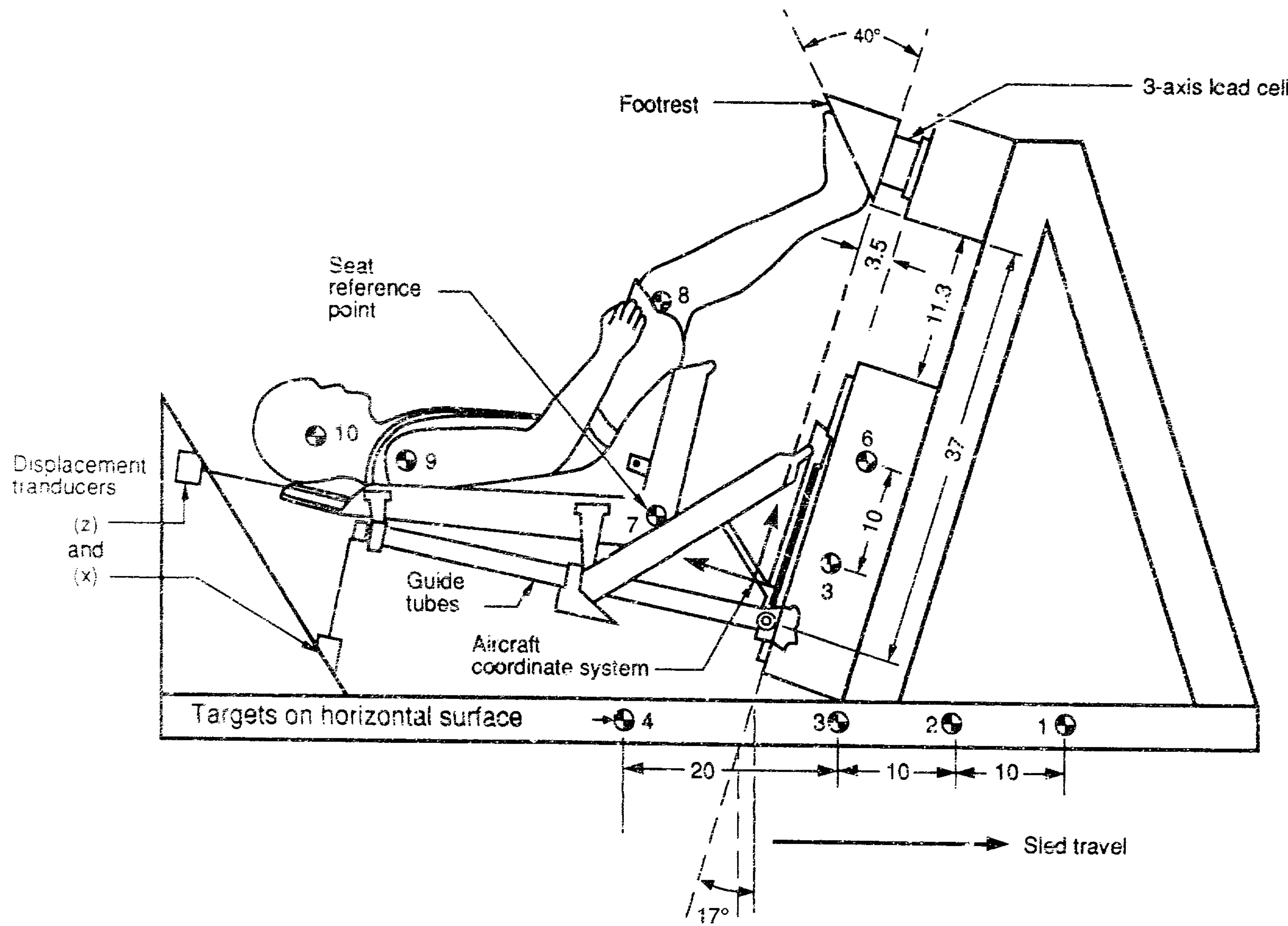


Figure 23. Configuration for dynamic test of energy-absorbing helicopter seat.

1	2	3	4	5	6	7	8
CAMI TEST A81-124 (ENERGY-ABSORBING HELICOPTER CREWSEAT)							00001000
44 FT/S, 42-G SLED TEST WITH 73-DEG PITCH							00002000
2 3	0 4	0 1	1 16	1 1	1 1	0 0	00003000
1 1	2 0	1 1	3 0	0 0	8 1	1	00004000
0.	0.250	0.001	0.001	0.1	0.001	0.001	00005000
0.025							00006000
0.0	0.0						00007000
0.025	0.0						00007010
0.050	0.0						00007020
0.075	0.0						00007030
0.100	0.0						00007040
0.125	0.0						00007050
0.150	0.0						00007060
0.175	0.0						00007070
760.	0.50	2.40	2.5				00008000
760.	0.50	2.40	1.5				00009000
1000.	0.216	2.40	1.0				00010000
1820.	5000.	10000.	0.0080	0.0520	0.0900		00011000
3.6	-9.0	13.1	3.6	9.0	13.1		00012000
910.	2500.	5000.	0.0080	0.0520	0.0900		00013000
-6.02	0.0	36.2	12.0	5.0			00014000
1000.	1570.	5000.	0.0133	0.0467	0.1112		00015000
13.18	0.0	10.2					00016000
0.0	0.0						00017000
0.30	0.35	0.0	0.0				00018000
0.0	0.0	0.0	0.0	-73.0	0.0		00019000
12.72	0.0	-41.60	0.0	0.0	0.0		00020000
0.0	0.0	0.0	0.0				00021000
0.0055	-0.841	0.0	2.75				00021010
0.0085	-1.68	0.0	5.50				00021020
0.0130	-3.22	0.0	10.53				00021030
0.0175	-4.32	0.0	14.15				00021040
0.0250	-7.33	0.0	23.97				00021050
0.0280	-8.32	0.0	27.23				00021060
0.0315	-9.25	0.0	30.25				00021070
0.0382	-10.23	0.0	33.48				00021080
0.0440	-11.72	0.0	38.35				00021090
0.0480	-12.13	0.0	39.68				00021100
0.0515	-11.65	0.0	38.11				00021110
0.0535	-10.25	0.0	33.52				00021120
0.0590	0.38	0.0	-1.26				00021130
0.0628	0.77	0.0	-2.52				00021140
0.0680	0.0	0.0	0.0				00021150
-13.0	-13.0	3.0	13.0	58.0	13.0	0.0	00022000

Figure 24. Listing of input data, case no. 3

1	2	3	4	5	6	7	8
10.85	8.35	11.3	13.3	16.5	18.0		00022001
4.67	6.55	6.33	4.72	6.26	8.35	10.96	00022002
34.60	35.97	12.08	4.85	4.85	21.70	9.49	00022003
2.32	2.18	0.275	0.132	0.017	0.127	0.927	00022004
0.76	0.93	0.284	0.135	0.185	1.22	0.994	00022005
2.32	1.70	0.233	0.022	0.195	0.873	0.505	00022006
4.50	4.50	3.44	1.95	1.85	3.10	2.30	00022007
2.30	1.60	3.56	2.61	1.85	2.34		00022008
3.70	6.34	0.20	0.20	2.00			00022009
2000.	0.050	2000.	0.380				00022010
6000.	0.238	1.00	3240.	0.270	1.00		00022011
375.0	1.49	150.0	375.0	1.49	30.0		00022012
0.0	7.50	3.00	13.0	16.0	18.0	40.5	00023000
60.6	4.0	4308.	0.55	148.0	3470000.	2000.	00024000
2585.	2585.	2585.	0.6	16.0	20.0		00025000
15510.	156350.	215160.	0.0156	0.0562	0.0885		00026000

Figure 24 (contd). Listing of input data, case no. 3.

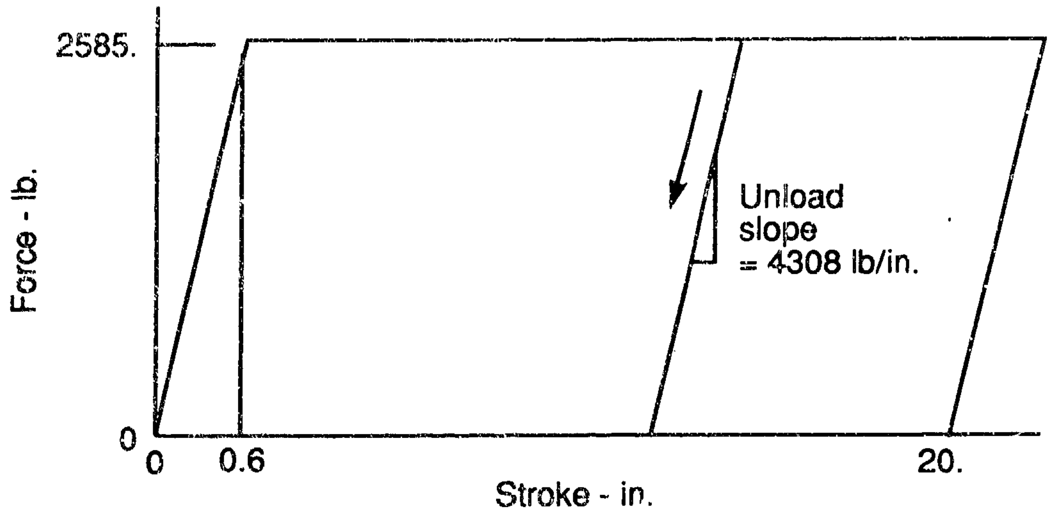


Figure 25. Energy absorber load-stroke characteristics

5.4 SAMPLE CASE NO. 4: SEAT BACK CONTACT

This example simulates one of a series of tests conducted at the FAA Civil Aeromedical Institute (CAMI), in which two rows of seats were installed on the deceleration sled. This test condition was intended primarily to observe the influence of aft-seated passengers on seat loading (Ref. 5). The first test conditions simulated are those of test A87-040, for which the seats were installed at a row pitch of 30 in. (SPITCH = 30.0 on Line 49), and the seat back movement on the forward seat was unrestricted. The "breakover" moment, which would resist the seat back's rotation, was set in the simulation at 60 lb-ft, the approximate lower end of the range measured by CAMI during their test program. The sled deceleration that was measured in the test was digitized and applied as input to the model; the digitized pulse is shown in Figure 26. A series of occupant plots showing the seat back rotation is included as Figure 27, and a complete listing in Figure 28.

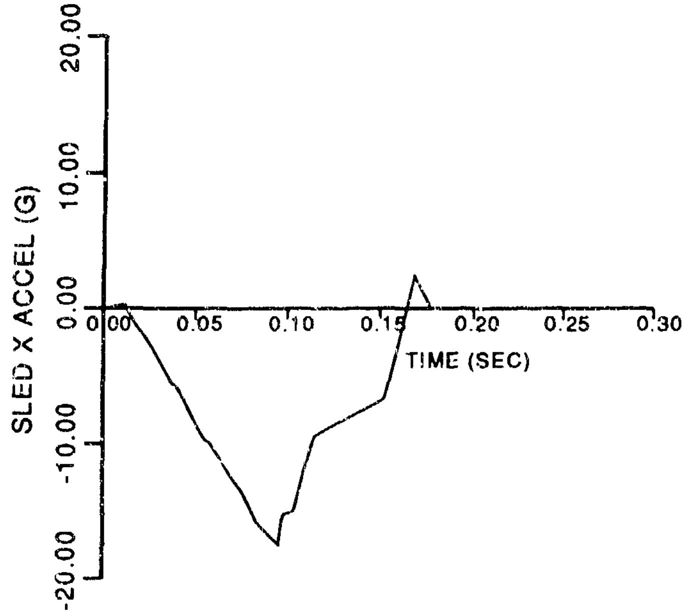


Figure 26. Test sled acceleration, test A87040.

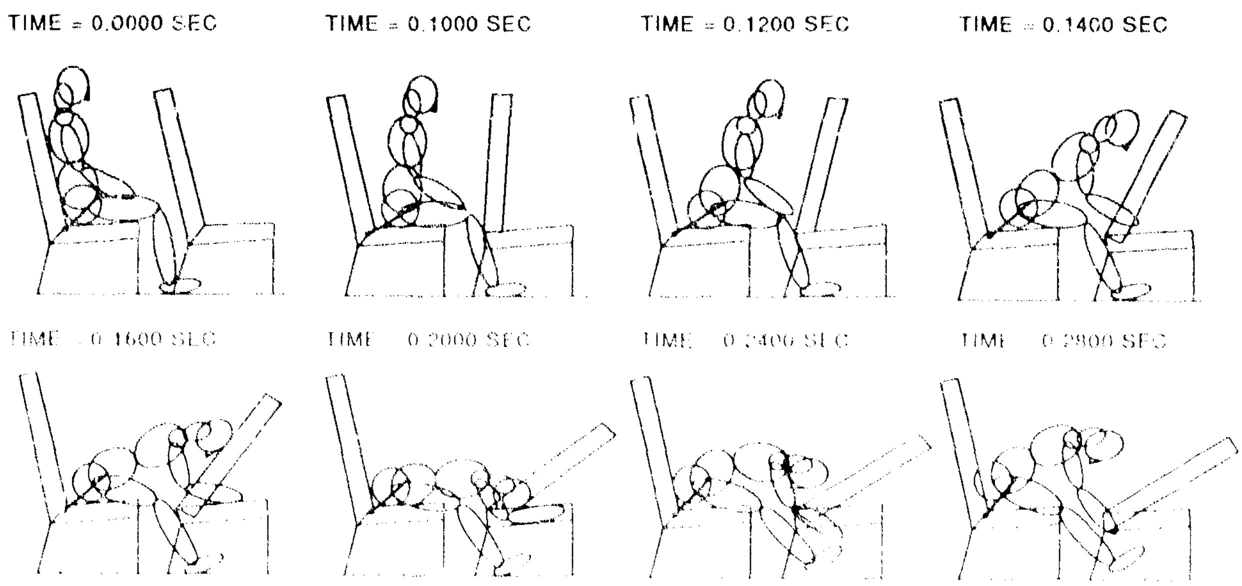


Figure 27. Occupant position, full seat back breakover.

```
         1         2         3         4         5         6         7         8
                  CAMI TEST A87040 (15-G, TWO SEAT ROWS)                 00001000
             RESTRICTED SEAT BACK BREAKOVER, 30-IN. ROW PITCH            00002000
    2    1    0    0    0    1    0   16    1    3    3    1    1    1 00003000
    1    1    2    1    1    1    2    0    0    0    8    1    2       00004000
       0.0     0.300    0.0005    0.0005      0.10     0.001    0.0005 00005000
      0.05                                                             00006000
       0.0       0.0                                                   00007000
     0.040       0.0                                                   00007010
     0.080       0.0                                                   00007020
     0.120       0.0                                                   00007030
     0.160       0.0                                                   00007040
     0.200       0.0                                                   00007050
     0.240       0.0                                                   00007060
     0.280       0.0                                                   00007070
     216.0      2.04      1.20       4.0                               00008000
     216.0      2.04      1.20       4.0                               00009000
     216.0      2.04      1.20       5.3                               00010000
      550.     1300.     2250.    0.0403    0.1048    0.1613        0. 00011000
       5.0     -27.0      14.5       5.0      -9.0      14.5           00012000
       5.0      -9.0      11.5       5.0       9.0      14.5           00012010
       5.0       3.0      14.5      14.5      27.0      14.5           00012020
       0.0                                                             00013000
       0.0                                                             00014000
       0.0                                                             00014010
       0.0                                                             00014020
       0.0                                                             00015000
       0.0                                                             00016000
       0.0                                                             00016010
       0.0                                                             00016020
       0.0       0.0                                                   00017000
      0.18      0.25       0.0       0.0                               00018000
       0.0       0.0       0.0       0.0       0.0       0.0           00019000
      44.2       0.0       0.0       0.0       0.0       0.0           00020000
       0.0       0.0                                                   00021000
    0.0118      0.23                                                   00021010
      0264     -2.65                                                   00021020
    0.0391     -5.65                                                   00021030
    0.0427     -6.00                                                   00021040
    0.0564      9.69                                                   00021050
    0.0582     -9.92                                                   00021060
    0.0764     13.50                                                   00021070
    0.0855    -15.04                                                   00021080
    0.0973    -17.54                                                   00021090
```

Figure 28   Listing of input data, case no. 4

1	2	3	4	5	6	7	8
0.1009	-15.23						00021100
0.1055	-15.23						00021110
0.1173	-9.46						00021120
0.1564	-6.69						00021130
0.1718	2.54						00021140
0.1800	0.00						00021150
-13.0	-13.0	10.0	-18.0	48.0	28.0	-18.0	00022000
-13.0	-13.0	10.0	-18.0	48.0	28.0	0.0	00022010
-13.0	-13.0	10.0	-18.0	48.0	28.0	18.0	00022020
2.2	11.1	5.00	13.0	20.0	18.0	46.0	00023000
							00024000
							00025000
							00026000
14.0	16.0	10.0	22.0	3.0	3.0	16.0	00045000
760.0	0.68	3.0					00046000
760.0	1.0	2.4					00047000
760.0	1.0	2.4					00048000
10.0	80.0	30.0					0004[illegible]00
720.0	720.0	3600 0	0.0349	1.274	1.623		00050[illegible]00

Figure 28 (contd). Listing of input data, case no. 4.

6.0 REFERENCES

1. D.H. Laananen, A.O. Bolukbasi, and J.W. Coltman, *Computer Simulation of an Aircraft Seat and Occupant in a Crash Environment, Volume I - Technical Report,* DOT/FAA/CT-82/33-I, Federal Aviation Administration Technical Center, Atlantic City Airport, New Jersey, March 1983.

2. A.O. Bolukbasi and D.H. Laananen, *Computer Simulation of a Transport Aircraft Seat and Occupant(s) in a Crash Environment, Volume I - Technical Report,* DOT/FAA/CT-86/25-I, Federal Aviation Administration Technical Center, Atlantic City Airport, New Jersey, August 1986.

3. D.H. Laananen, J.W. Coltman, and A.O. Bolukbasi, *Computer Simulation of an Aircraft Seat and Occupant in a Crash Environment, Volume II - Program SOM-LA User Manual,* DOT/FAA/CT-82/33-II, Federal Aviation Administration Technical Center, Atlantic City Airport, New Jersey, March 1983.

4. A.O. Bolukbasi and D.H. Laananen, *Computer Simulation of a Transport Aircraft Seat and Occupant(s) in a Crash Environment, Volume II - Program SOM-TA User Manual,* DOT/FAA/CT-86/25-II, Federal Aviation Administration Technical Center, Atlantic City Airport, New Jersey, August 1986.

5. R.F. Chandler and R.V. Gowdy, *Loads Measured during Passenger Seat Tests,* Memorandum Report AAC-119-81-8A, Protection and Survival Laboratory, Civil Aeromedical Institute, Federal Aviation Administration, Oklahoma City, Oklahoma, March 1985

APPENDIX A

INPUT DATA REQUIREMENTS

In this Appendix, a line-by-line description of the input data required by Program SOM-LA/SOM-TA for example no. 1, described in section 5.1, is presented. As described in section 2, there are also a number of optional lines of data, such as Lines 22A through 22L, which are used only for a nonstandard occupant. These are included following the Line 22 input, beginning on page A-32. Lines 24 through 26 for the energy-absorbing seat option are not used in example no. 1 and are, therefore, blank. An example of their use can be found in example no. 3, described in section 5.3. Data for the finite element seat model begins with Line 27, which follows page A-57.

Input data for modeling contact between occupants and the seat backs in front of them, used in example no. 4, begin on page A-81, following the input for example no. 1.

LINES 1 AND 2: Case Identification

DESCRIPTION: Title of case on two lines.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NAME1						
NAME2						
THREE-PASSENGER TRANSPORT AIRCRAFT SEAT						
SAMPLE CASE NO. 1						

FIELD	FORMAT	CONTENTS
NAME1	7A10	Alphanumeric title of case to be centered at top of printed output and plots.
NAME2	7A10	Second line of alphanumeric data.

LINE 3: Case Control Parameters

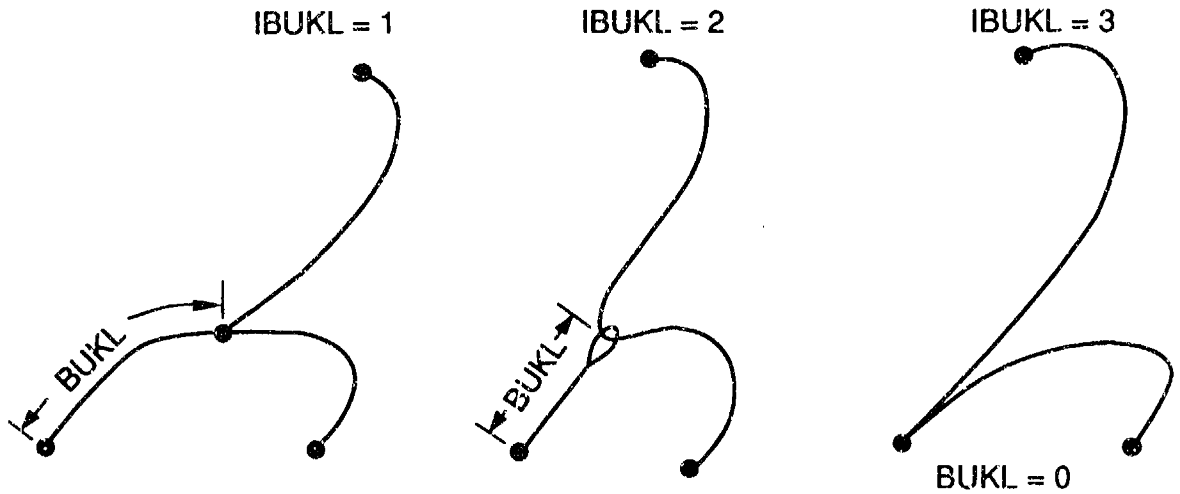
DESCRIPTION: Type of case, type of seat, and occupant locations.

FORMAT AND EXAMPLE:

	1		2		3		4		5		6		7
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890	
NDIM	IMAN	NSEAT	IRSYS	IBUKL	ILBLT	ISHNS	NIMPT	NUNIT	NOCC	ITYPE	ISEAT (1)	ISEAT (2)	ISEAT (3)
2	1	1	0	0	1	0	4	1	3	3	1	1	1

FIELD	FORMAT	CONTENTS
NDIM	I5	Definition of occupant degrees of freedom NDIM = 2 : Two-dimensional (plane motion) simulation NDIM = 3 : Three-dimensional simulation (default).
IMAN	I5	Identification of occupant IMAN = 0 : Standard 50th-percentile male human IMAN = 1 : Standard 50th-percentile (Part 572) dummy IMAN = 2 : Nonstandard human IMAN = 3 : Nonstandard dummy.
NSEAT	I5	Seat model NSEAT = 0 : Rigid seat model NSEAT = 1 : Finite element seat model.
IRSYS	I5	Restraint system configuration IRSYS = 0 : Lap belt only IRSYS = 1 : Diagonal shoulder belt over right shoulder IRSYS = 2 : Diagonal shoulder belt over left shoulder IRSYS = 3 : Double shoulder belt.
IBUKL	I5	Buckle connection type (see Figure A-1).
ILBLT	I5	Lap belt attachment ILBLT = 0 : Attached to airframe ILBLT = 1 : Attached to seat.
ISHNS	I5	Shoulder harness attachment ISHNS = 0 : Attached to airframe ISHNS = 1 : Attached to seat.
NIMPT	I5	Number of points in table of aircraft acceleration vs. time (determines number of Line 21 inputs required, a maximum of 40).
NUNIT	I5	System of units NUNIT = 0 : SI units NUNIT = 1 : English units.
NOCC	I5	Number of occupants to be modeled.

ITYPE	I5	Seat type in terms of occupant positions ITYPE = 1 : Single seat ITYPE = 2 : Two-passenger seat ITYPE = 3 : Three-passenger seat.
ISEAT	3I5	Locations of occupants, specifying whether a given seat position is occupied (1) or empty (0) ISEAT(1) : Right-most position ISEAT(2) : Center position for three-passenger seat, left position for two-passenger seat ISEAT(3) : Left position for three-passenger seat.



1 = Shoulder belt fixed to buckle
2 = Shoulder belt and one side of lap belt are one length of webbing
3 = Shoulder belt and lap belt attached to fixed point

NOTE: BUKL parameter is defined on lines 14A, 14B, and 14C.

Figure A-1. Types of buckle connections specified by IBUKL on line 3.

LINE 4: Output Selection

DESCRIPTION: Definition of output data to be stored for printing and number of plots.

FORMAT AND EXAMPLE:

	1		2		3		4		5		6		7
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890	
IOUT(1)	IOUT(2)	IOUT(3)	IOUT(4)	IOUT(5)	IOUT(6)	IOUT(7)	IOUT(8)	IOUT(9)	IOUT (10)	NOPLT	ITRMX	IPASS	
1	1	2	0	1	1	2	1	1	1	8	5	2	

FIELD	FORMAT	CONTENTS
IOUT	10I5	Vector of 0's, 1's, 2's and 3's indicating which output data are to be printed (1, 2, or 3) or not printed (0) IOUT(1) : Occupant segment position IOUT(2) : Occupant segment velocity IOUT(3) : Occupant segment acceleration(1) IOUT(4) : Secondary impact prediction(2) IOUT(5) : Restraint system forces IOUT(6) : Injury criteria IOUT(7) : Seat external loads (cushions, floor) (1) IOUT(8) : Seat structure deflections(3) IOUT(9) : Seat structure support reactions IOUT(10): Stresses in seat structure beam elements(4).
NOPLT	I5	Number of requested occupant position plots (up to 20). (Determines number of Line 7 inputs to be included.)
ITRMX	I5	Number of iterations in initially seating occupant(s). (Default = 5.)
IPASS	I5	Identification of occupant for which output data (position, velocity, acceleration, belt loads, etc.) are stored and printed IPASS = 1 : Right-most passenger IPASS = 2 : Center position for three-passenger seat or left position for two-passenger seat IPASS = 3 : Left position for three-passenger seat.

The example specifies a three-passenger seat which is fully occupied. Output data are stored and printed for the center passenger.

---

(1) For IOUT(3) and IOUT(7), an input value of 1 results in unfiltered output. A value of 2 or 3 results in application of a class 180 (300 Hz) or class 60 (100 Hz) filter, respectively.

(2) IOUT(4) = 0 : No secondary impact prediction and the forward seat is not plotted.
IOUT(4) = 1 : Subroutine IMPACT is called for prediction of contact with the seat back, and occupant plots show the forward seat in its undeformed position.
IOUT(4) = 2 : Subroutine IMPACT is called for prediction of contact with the seat back, and occupant plots show the forward seat deformation as that of the seat being modeled.

(3) If IOUT(8) = 1, data on Line 30 will be used to select the nodes for stress output deflection output.

(4) If IOUT(10) = 1, data on Line 31 will be used to select the beam elements for stress output.

LINE 5: Simulation Control Data

DESCRIPTION: Parameters for control of solution duration, step size, and error bounds.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TI	TF	DMAX	DMIN	EUR	ELR	DTI
0.0	0.180	0.0005	0.0005	0.10	0.001	0.0005

FIELD	FORMAT	CONTENTS
TI	F10.0	Initial solution time in seconds. Normally taken as 0.
TF	F10.0	Final solution time in seconds.
DMAX	F10.0	Maximum step size. A value of 0.001 sec has been used successfully.
DMIN	F10.0	Minimum step size. A value as large as 0.001 sec has been used successfully, but the use of very stiff restraint system webbing or seat cushions may require a smaller value, such as 0.00001. The solution can be accomplished with a fixed step size by setting DMIN = DMAX.
EUR	F10.0	Maximum bound on error between predictor and corrector. A value of 0.05 to 0.10 is suggested, corresponding to a range of 5 to 10 percent. If the error in any variable is larger than this value, the step size is halved, maintaining solution accuracy.
ELR	F10.0	Lower bound on error between predictor and corrector. A value of 0.001 is suggested, corresponding to 0.1 percent. If the error in all variables is smaller than this value, the step size is doubled, preventing the computer execution cost from becoming excessively high. Note: Because doubling the step size multiplies the truncation error in the Adams-Moulton integrator by a factor of 2^5, ELR should be chosen less then EUR/32 if the advantages of doubling are not to be short-lived.
DTI	F10.0	Initial step size, normally set equal to DMIN.

LINE 6: Restart Data Interval

DESCRIPTION: Time interval at which data are to be written on unit 25 for potential use in subsequently restarting solution.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CKPTIN						
0.025						

FIELD	FORMAT	CONTENTS
CKPTIN	F10.0	Time interval in seconds.

LINE 7: Occupant Plot Times and Viewing Angles (number of lines required = NOPLT on Line 4)

DESCRIPTION: Times when occupant plot data are to be stored on unit 14, which must be saved as a permanent file for subsequent plotting. Viewing angles corresponding to times are measured in degrees in the horizontal plane, as illustrated in Figure A-2. An angle of 0 degrees results in a right-side view; 90 degrees, a front view; and 180 degrees, a left-side view.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TOPLT	ANGVU					
0.0	0.0					
0.025	0.0					
0.050	0.0					
0.075	0.0					
0.100	0.0					
0.125	0.0					
0.150	0.0					
0.175	0.0					

FIELD	FORMAT	CONTENTS
TOPLT	F10.0	Plot time (sec).
ANGVU	F10.0	Occupant viewing angles (deg).

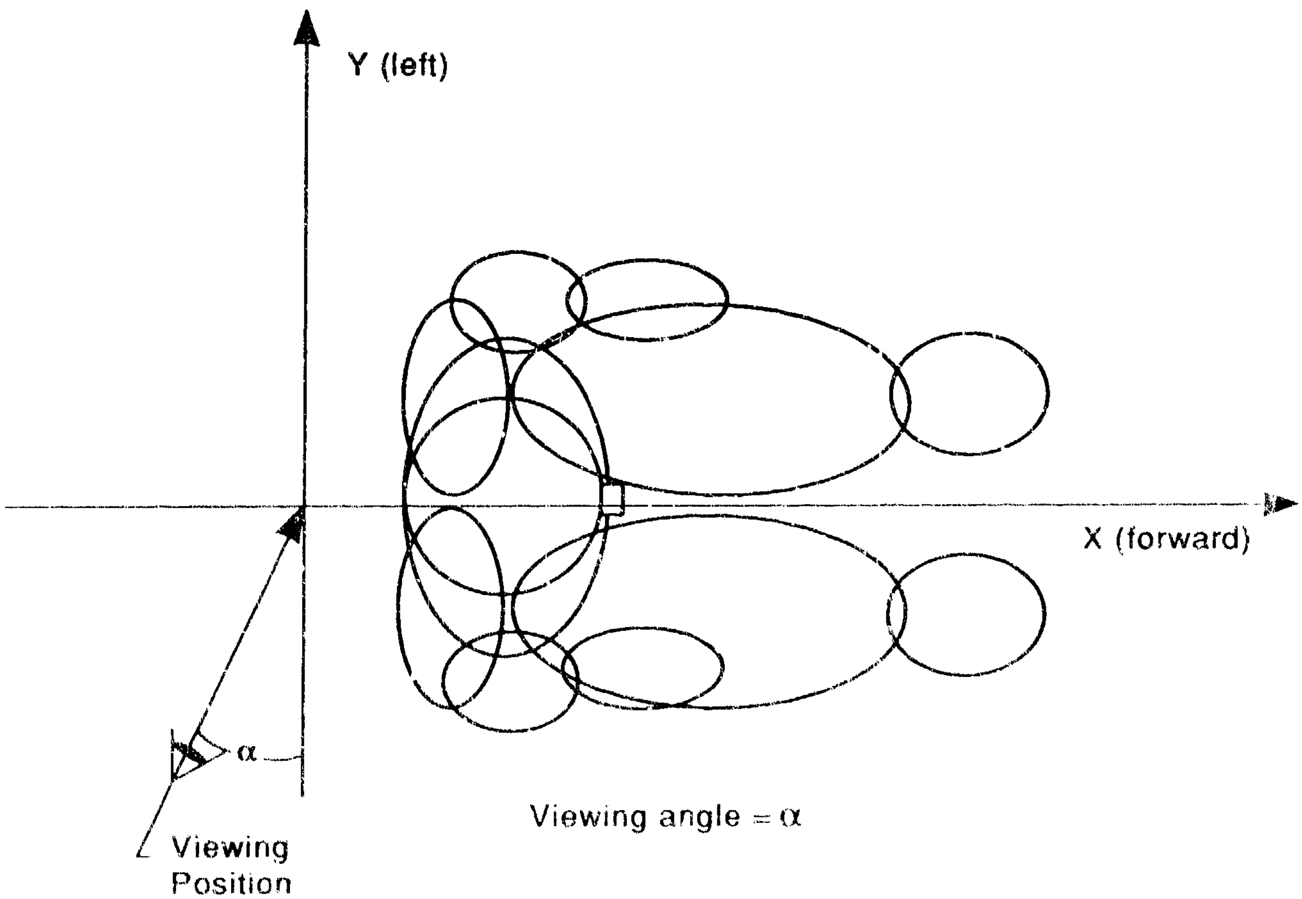


Figure A-2. Definition of occupant plot viewing angle.

LINE 8: Combined Seat Cushion and Occupant Buttocks Properties

DESCRIPTION: Force-deflection characteristics and damping for seat cushion and buttocks combined; thickness for seat bottom cushion. The force, F, is computed from total deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CSC	BSC	DPSC	THSCE			
760.	0.50	2.40	1.50			

FIELD	FORMAT	CONTENTS
CSC	F10.0	Coefficient C in above equation (lb).
BSC	F10.0	Coefficient B in above equation ($in.^{-1}$).
DPSC	F10.0	Damping coefficient at zero load (lb-sec/in.)
THSCE	F10.0	Unloaded thickness of cushion under buttocks (in.)

LINE 9: Back Cushion Properties

DESCRIPTION: Force-deflection characteristics, damping, and thickness for back cushion. These characteristics should be measured using an indenter with the form of the occupant torso. If a dummy torso is used in measurement, the deflection should be based on the chest accelerometer location. The force, F, is computed from cushion deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CBC	BBC	DPBC	THBCE			
760.	0.50	2.40	1.50			

FIELD	FORMAT	CONTENTS
CBC	F10.0	Coefficient C in above equation (lb).
BBC	F10.0	Coefficient B in above equation ($in.^{-1}$).
DPBC	F10.0	Damping coefficient at zero load (lb-sec/in.)
THBCE	F10.0	Unloaded thickness of cushion in center of seat back (in.).

LINE 10: Headrest Cushion Properties

DESCRIPTION: Force-deflection characteristics, damping, and thickness for headrest cushion. The measurement should be made using a headform. The force, F, is computed from cushion deflection, δ, according to $F = C(e^{B\delta} - 1)$. If CHR = 0 (or blank), the headrest is omitted from the seat configuration.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CHR	BHR	DPHR	THHRE			
760.	0.50	2.40	3.0			

FIELD	FORMAT	CONTENTS
CHR	F10.0	Coefficient C in above equation (lb).
BHR	F10.0	Coefficient B in above equation ($in.^{-1}$).
DPHR	F10.0	Damping coefficient (lb-sec/in.).
THHRE	F10.0	Unloaded thickness of cushion behind head (in.).

LINE 11: Lap Belt Properties

DESCRIPTION: Tables of forces and deflections define an approximation to force-deflection curve by three linear segments, as illustrated in Figure A-3. The force and deflection at point 1 are assumed to be zero.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFLB(2)	FFLB(3)	FFLB(4)	DDLB(2)	DDLB(3)	DDLB(4)	
550.	1300.	2250.	0.0403	0.1048	0.1613	

FIELD	FORMAT	CONTENTS
FFLB	3F10.0	Forces (lb).
DDLB	3F10.0	Strains corresponding to forces ([illegible]n.).

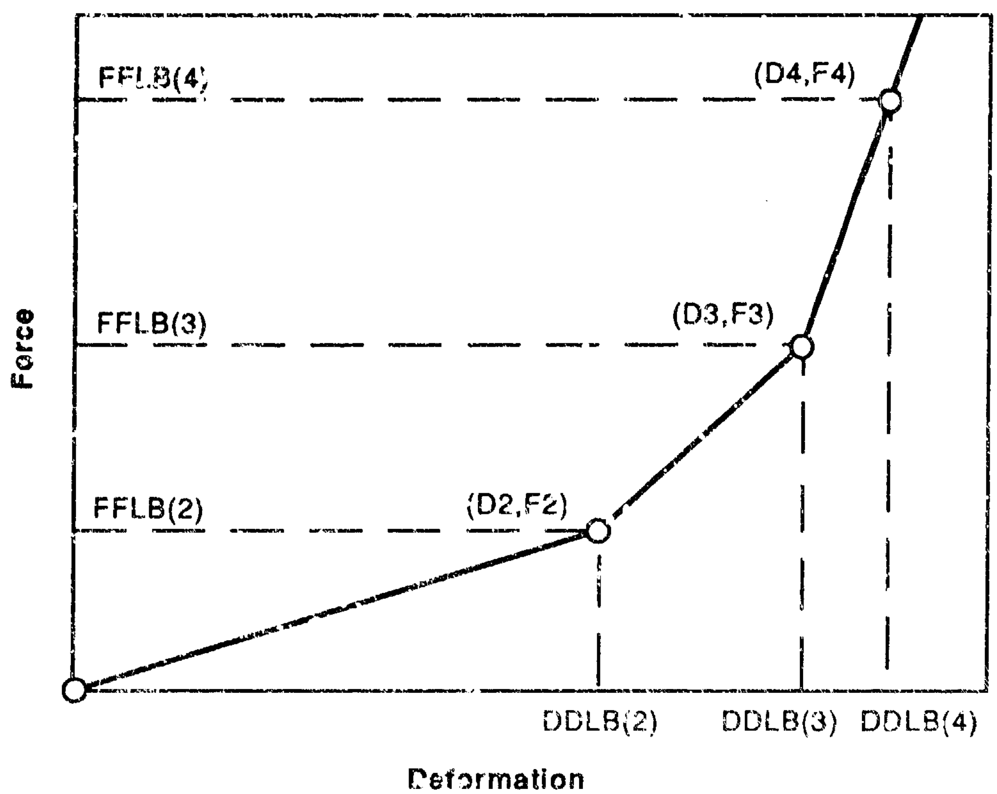


Figure A-3. Force-deflection model for restraint system webbing.

LINE 12A: Lap Belt Anchor Points and Footrest, Passenger No. 1*

DESCRIPTION: Coordinates of right and left lap belt anchor points in aircraft coordinate system.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLB(1,1)	YLB(1,1)	ZLB(1,1)	XLB(2,1)	YLB(2,1)	ZLB(2,1)	
12.5	-30.0	15.0	12.5	-10.0	15.0	

FIELD	FORMAT	CONTENTS
XLB(1,1) YLB(1,1) ZLB(1,1)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.)
XLB(2,1) YLB(2,1) ZLB(2,1)	3F10.0	Coordinates of left-hand lap belt anchor point in aircraft coordinate system (in.).

*Included only if ISEAT(1) = 1 on Line 3.

LINE 12B: Lap Belt Anchor Points and Footrest, Passenger No. 2*

DESCRIPTION: Coordinates of right and left lap belt anchor points in aircraft coordinate system.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLB(1,2)	YLB(1,2)	ZLB(1,2)	XLB(2,2)	YLB(2,2)	ZLB(2,2)	
12.5	-10.0	15.0	12.5	10.0	15.0	

FIELD	FORMAT	CONTENTS
XLB(1,2) YLB(1,2) ZLB(1,2)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.).
XLB(2,2) YLB(2,2) ZLB(2,2)	3F10.0	Coordinates of left-hand lap belt anchor point in aircraft coordinate system (in.).

*Included only if ITYPE > 1 and ISEAT(2) = 1 on Line 3.

LINE 12C: Lap Belt Anchor Points and Footrest, Passenger No. 3*

DESCRIPTION: Coordinates of right and left lap belt anchor points in aircraft coordinate system.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLB(1,3)	YLB(1,3)	ZLB(1,3)	XLB(2,3)	YLB(2,3)	ZLB(2,3)	
12.5	10.0	15.0	12.5	30.0	15.0	

FIELD	FORMAT	CONTENTS
XLB(1,3) YLB(1,3) ZLB(1,3)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.).
XLB(2,3) YLB(2,3) ZLB(2,3)	3F10.0	Coordinates of left-hand lap belt anchor point in aircraft coordinate system (in.).

*Included only if ITYPE = 3 and ISEAT(3) = 1 on Line 3.

LINE 13: Shoulder Belt Properties (used only if IRSYS > 0)*

DESCRIPTION: Tables of forces and deflections define an approximation to force-deflection curve by three linear segments, as illustrated in Figure A-3. The force and deflection at point 1 are assumed to be zero.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFSH(2)	FFSH(3)	FFSH(4)	DDSH(2)	DDSH(3)	DDSH(4)	

FIELD	FORMAT	CONTENTS
FFSH	3F10.0	Forces (lb).
DDSH	3F10.0	Strain corresponding to forces (in./in.).

*Not used in sample case, therefore blank.

LINE 14A, 14B, 14C: Shoulder Belt Anchor Points (used only if IRSYS > 0)*

DESCRIPTION: Coordinates of shoulder belt anchor point in aircraft coordinate system.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XSH(1)	YSH(1)	ZSH(1)	BUKL(1)	XTRAL(1)		
XSH(2)	YSH(2)	ZSH(3)	BUKL(2)	XTRAL(2)		
XSH(3)	YSH(3)	ZSH(3)	BUKL(3)	XTRAL(3)		

FIELD	FORMAT	CONTENTS
XSH(1) YSH(1) ZSH(1)	3F10.0	Coordinates of shoulder belt anchor point in aircraft coordinate system, or point from which belt passes to shoulder in a straight line.
BUKL	F10.0	Length of lap belt webbing attached to buckle, as illustrated in Figure A-1.
XTRAL	F10.0	Length of shoulder strap beyond (XSH, YSH, ZSH) if strap is not in straight line from anchor point to shoulder, as shown in Figure A-4 (not used if IRSYS = 0).

Lines 14B and 14C repeat Line 14A for passengers 2 and 3; they are included only if NOCC>1.

* Not used in sample case, therefore blank.

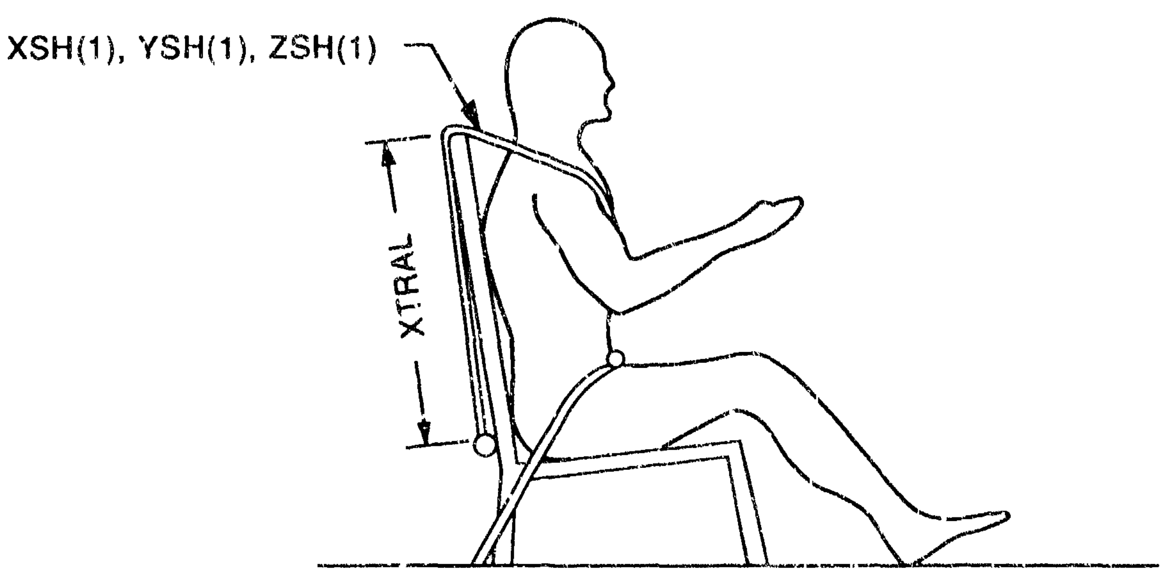


Figure A-4. XTRAL dimensions for shoulder belts on line 14.

LINE 15: Tiedown Strap Properties (used only if IRSYS = 4)*

DESCRIPTION: Table of forces and deflections define an approximation to force-deflection curve by three linear segments, as illustrated in Figure A-3. The force and deflection at point 1 are assumed to be zero.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFTD(2)	FFTD(3)	FFTD(4)	DDTD(2)	DDTD(3)	DDTD(4)	

FIELD	FORMAT	CONTENTS
FFTD	3F10.0	Forces (lb).
DDTD	3F10.0	Strain corresponding to forces (in./in.).

* Not used in sample case, therefore blank.

LINE 16A, 16B, 16C: Tiedown Strap Anchor Points (used only if IRSYS = 4)*

DESCRIPTION: Coordinates of lap belt tiedown strap anchor points in aircraft coordinate system.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XTD(1)	YTD(1)	ZTD(1)				
XTD(2)	YTD(2)	ZTD(2)				
XTD(3)	YTD(3)	ZTD(3)				

FIELD	FORMAT	CONTENTS
XTD(1) YTD(1) ZTD(1)	3F10.0	Coordinates of right-hand lap belt anchor point in aircraft coordinate system (in.).

Lines 16B and 16C repeat Line 16A for passengers 2 and 3; they are included only if NOCC>1.

*Not used in sample case, therefore blank

LINE 17: Additional Belt Properties

DESCRIPTION: Damping coefficient and belt slack for lap belt, shoulder belt(s), and tiedown strap.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
DPLB	SLAB	DPSH	SLSH	DPTD	SLTD	
0.0	0.0					

FIELD	FORMAT	CONTENTS
DPLB	F10.0	Lap belt damping coefficient (lb-sec).
SLAB	F10.0	Lap belt slack (in.).
DPSH	F10.0	Shoulder belt damping coefficient (lb-sec).
SLSH	F10.0	Shoulder belt slack (in.).
DPTD	F10.0	Tiedown strap damping coefficient (lb-sec).
SLTD	F10.0	Tiedown strap slack (in.).

LINE 18: Other seating and restraint data

DESCRIPTION: Friction coefficients and footrest location.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
COEFFS	COEFFR	XFR	ANGFR			
0.18	0.25	0.0	0.0			

FIELD	FORMAT	CONTENTS
COEFFS	F10.0	Seat cushion friction coefficient.
COEFFR	F10.0	Floor-foot friction coefficient.
XFR	F10.0	X-coordinate of footrest in aircraft coordinate system, at intersection with floor, where Z = 0.
ANGFR	F10.0	Angle between footrest and floor in degrees.

LINE 19: Aircraft Initial Position

DESCRIPTION: Components of aircraft initial position, in earth-fixed coordinate system, and attitude.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XA	YA	ZA	YAW	PITCH	ROLL	
0.0	0.0	0.0	0.0	0.0	0.0	

FIELD	FORMAT	CONTENTS
XA YA ZA	3F10.0	Position of aircraft coordinate system in inertial system (earth-fixed system in which gravity acts in the -Z direction) (in.). These initial coordinates are normally taken as (0., 0., 0.) unless displacement from a specific point is desired. For example, if the simulation is to be initiated at some horizontal distance from a barrier, such as 60 in., the initial position could be specified as (-60., 0., 0.). If the simulation is to begin 10 in. above the ground in a vertical drop, the initial position could be specified as (0., 0., 10.). These coordinates are not used in the simulation but only in output of aircraft position.
YAW PITCH ROLL	3F10.0	Initial attitude of aircraft relative to earth-fixed system (deg).

LINE 20: Aircraft Initial Velocity

DESCRIPTION: Components of aircraft initial velocity, in aircraft coordinate system, translation and rotation.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
VX	VY	VZ	DYAW	DPITCH	DROLL	
30.0	0.0	0.0	0.0	0.0	0.0	

FIELD	FORMAT	CONTENTS
VX VY VZ	3F10.0	Components of aircraft initial velocity in aircraft coordinate system (ft/sec).
DYAW DPITCH DROLL	3F10.0	Yaw, pitch, and roll rates (rad/sec).

LINE 21: Aircraft Acceleration

DESCRIPTION: The time variation of the six components of the acceleration of the aircraft coordinate system is approximated by up to 40 points in acceleration and time. NIMPT lines must be included (up to 40).

FORMAT AND EXAMPLE: (4 lines for NIMPT = 4 on Line 3.)

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TA	AX	AY	AZ	AYAW	APIT	AROL
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.010	-6.0	0.0	0.0	0.0	0.0	0.0
0.155	-6.0	0.0	0.0	0.0	0.0	0.0
0.165	0.0	0.0	0.0	0.0	0.0	0.0

FIELD	FORMAT	CONTENTS
TA	F10.0	Time (sec).
AX	F10.0	X-acceleration (G).
AY	F10.0	Y-acceleration (G).
AZ	F10.0	Z-acceleration (G).
AYAW	F10.0	Yaw acceleration (rad/sec/sec).
APIT	F10.0	Pitch acceleration (rad/sec/sec).
AROL	F10.0	Roll acceleration (rad/sec/sec).

LINE 22: Occupant Initial Position, Passenger No. 1

DESCRIPTION: Initial position angles and heel X-position, as illustrated in Figure A-5. The heels are assumed to begin at Z = 0. The torso is aligned according to GAM(1,1), GAM(2,1), and GAM(3,1), and the position is then determined from static equilibrium, allowing for compression of the cushions. Also, the Y-coordinate of the occupant plane of symmetry is included. (Line 22 must be included for each occupant, three in this example.)

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
GAM(1,1)	GAM(2,1)	GAM(3,1)	GAM(4,1)	GAM(5,1)	XHEEL(1)	YPASS(1)
-16.0	-16.0	7.0	-16.0	60.0	32.0	-20.0

FIELD	FORMAT	CONTENTS
GAM(I,1)	5F10.0	Vector of initial position angular coordinates, as illustrated in Figure A-5 (deg).
XHEEL(1)	F10.0	X-coordinate of heels in aircraft coordinate system (in.).
YPASS(1)	F10.0	Y-coordinate of mid-plane (plane of symmetry) for occupant (in.).

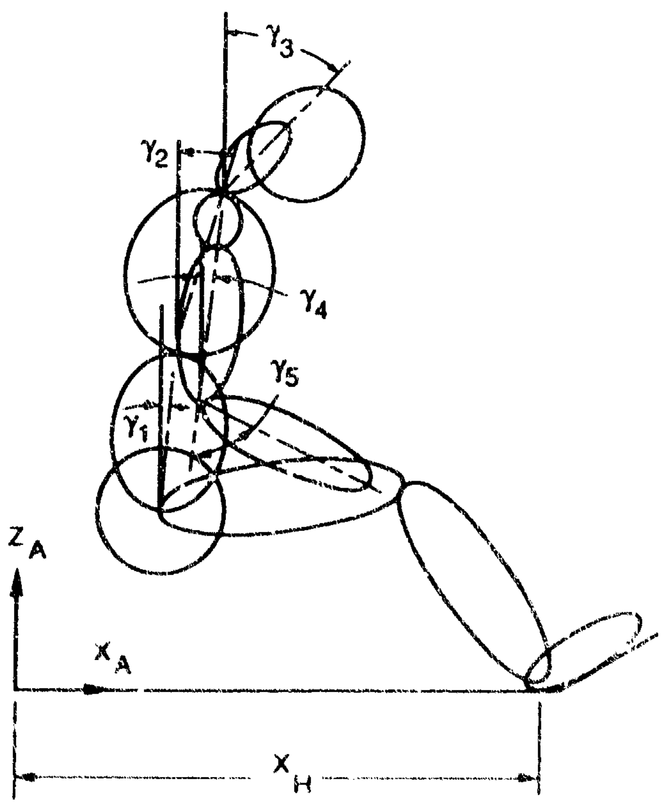


Figure A 5 Occupant initial position input data.

LINE 22: Occupant Initial Position, Passenger No. 2 (included only if NOCC>1)

DESCRIPTION: Initial position angles and heel X-position, as illustrated in Figure A-5. The heels are assumed to begin at Z = 0. The torso is aligned according to GAM(1,2), GAM(2,2), and GAM(3,2), and the position is then determined from static equilibrium, allowing for compression of the cushions. Also, the Y-coordinate of the occupant plane of symmetry is included.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
GAM(1,2)	GAM(2,2)	GAM(3,2)	GAM(4,2)	GAM(5,2)	XHEEL(2)	YPASS(2)
-16.0	-16.0	7.0	-16.0	60.0	32.0	0.0

FIELD	FORMAT	CONTENTS
GAM(I,2)	5F10.0	Vector of initial position angular coordinate, as illustrated in Figure A-5 (deg).
XHEEL(2)	F10.0	X-coordinate of heels in aircraft coordinate system (in.).
YPASS(2)	F10.0	Y-coordinate of mid-plane (plane of symmetry) for occupant (in.).

LINE 22: Occupant Initial Position, Passenger No. 3 (included only if NOCC = 3)

DESCRIPTION: Initial position angles and heel X-position, as illustrated in Figure A-5. The heels are assumed to begin at Z = 0. The torso is aligned according to GAM(1,3), GAM(2,3), and GAM(3,3), and the position is then determined from static equilibrium, allowing for compression of the cushions. Also, the Y-coordinate of the occupant plane of symmetry is included.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
GAM(1,3)	GAM(2,3)	GAM(3,3)	GAM(4,3)	GAM(5,3)	XHEEL(3)	YPASS(3)
-16.0	-16.0	7.0	-16.0	60.0	32.0	20.0

FIELD	FORMAT	CONTENTS
GAM(I,3)	5F10.0	Vector of initial position angular coordinate, as illustrated in Figure A-5 (deg).
XHEEL(3)	F10.0	X-coordinate of heels in aircraft coordinate system (in.).
YPASS(3)	F10.0	Y-coordinate of mid-plane (plane of symmetry) for occupant (in.).

LINE 22A-22L: Nonstandard Occupant Input Data*

If nonstandard occupants are requested by setting IMAN = 2 (human) or IMAN = 3 (dummy) on Line 3, then 12 additional lines must be inserted for each occupant. The format for these 12 lines, referred to as 22A - 22L, is explained on the following 15 pages. If IMAN = 0 (standard 50th-percentile human) or IMAN = 1 (standard 50th-percentile dummy), skip this section and proceed to Line 23.

*These lines must be provided for each occupant after each Line 22 specifying corresponding occupant initial position. They are not included in the sample case, but an example is provided in Appendix B.

LINE 22A: Segment Lengths (only if IMAN = 2 or 3)

DESCRIPTION: Lengths of the spine and segments 3, 4, 5, 8, and 9 as described in Figure A-6. The lengths of segments 6, 7, 10, and 11 are obtained from these by symmetry (in.).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SPL	XL(3)	XL(4)	XL(5)	XL(8)	XL(9)	

FIELD	FORMAT	CONTENTS
SPL	F10.0	Spinal length.
XL(3)	F10.0	Head length.
XL(4)	F10.0	Upper arm length.
XL(5)	F10.0	Lower arm length - elbow to mid-point of hand.
XL(8)	F10.0	Upper leg length.
XL(9)	F10.0	Lower leg length - knee to ankle.

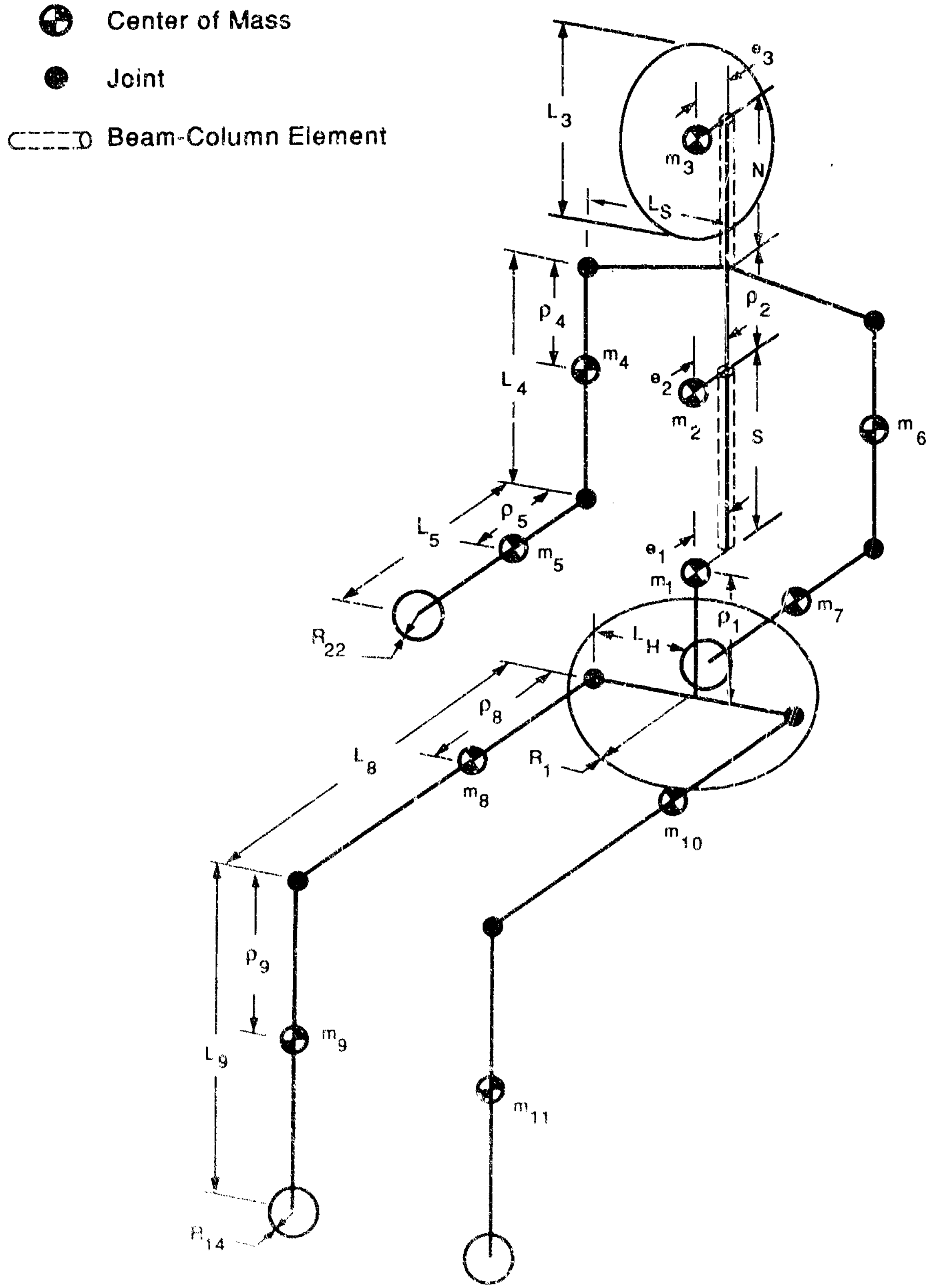


Figure A-6. Body segment dimensions

LINE 22B: Segment Center of Mass Location (only if IMAN = 2 or 3)

DESCRIPTION: Center of mass locations for segments 1, 2, 3, 4, 5, 8, and 9. See Figure A-6 for datum plane description (in.).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
RHO(1)	RHO(2)	RHO(3)	RHO(4)	RHO(5)	RHO(8)	RHO(9)

FIELD	FORMAT	CONTENTS
RHO(1)	F10.0	Lower torso center of mass vertical distance from hip pivot.
RHO(2)	F10.0	Upper torso center of mass distance from base of neck.
RHO(3)	F10.0	Head center of mass distance from base of neck.
RHO(4)	F10.0	Upper arm center of mass distance from shoulder pivot.
RHO(5)	F10.0	Lower arm center of mass distance from elbow pivot.
RHO(8)	F10.0	Upper leg center of mass distance from hip pivot.
RHO(9)	F10.0	Lower leg center of mass distance from knee pivot.

LINE 22C: Segment Weight (only if IMAN = 2 or 3)

DESCRIPTION: Weights of segments 1, 2, 3, 4, 5, 8, and 9 (lb).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SW(1)	SW(2)	SW(3)	SW(4)	SW(5)	SW(8)	SW(9)

FIELD	FORMAT	CONTENTS
SW(1)	F10.0	Lower torso weight.
SW(2)	F10.0	Upper torso weight.
SW(3)	F10.0	Head/neck weight.
SW(4)	F10.0	Upper arm weight.
SW(5)	F10.0	Lower arm weight.
SW(8)	F10.0	Upper leg weight.
SW(9)	F10.0	Lower leg weight.

LINE 22D: Segment Moment of Inertia with Respect to Local x-axis (only if IMAN = 2 or 3)

DESCRIPTION: Moments of inertia with respect to x-axis for segments 1, 2, 3, 4, 5, 8, and 9 (lb-in.-sec^2).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CIX(1)	CIX(2)	CIX(3)	CIX(4)	CIX(5)	CIX(8)	CIX(9)

FIELD	FORMAT	CONTENTS
CIX(1)	F10.0	Lower torso x-axis moment of inertia.
CIX(2)	F10.0	Upper torso x-axis moment of inertia.
CIX(3)	F10.0	Head/neck x-axis moment of inertia.
CIX(4)	F10.0	Upper arm x-axis moment of inertia.
CIX(5)	F10.0	Lower arm x-axis moment of inertia.
CIX(8)	F10.0	Upper leg x-axis moment of inertia.
CIX(9)	F10.0	Lower leg x-axis moment of inertia.

LINE 22E: Segment Moment of Inertia with Respect to Local y-axis (only if IMAN = 2 or 3)

DESCRIPTION: Moments of inertia with respect to y-axis for segments 1, 2, 3, 4, 5, 8, and 9 (lb-in.-sec^2).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CIY(1)	CIY(2)	CIY(3)	CIY(4)	CIY(5)	CIY(8)	CIY(9)

FIELD	FORMAT	CONTENTS
CIY(1)	F10.0	Lower torso y-axis moment of inertia.
CIY(2)	F10.0	Upper torso y-axis moment of inertia.
CIY(3)	F10.0	Head/neck y-axis moment of inertia.
CIY(4)	F10.0	Upper arm y-axis moment of inertia.
CIY(5)	F10.0	Lower arm y-axis moment of inertia.
CIY(8)	F10.0	Upper leg y-axis moment of inertia.
CIY(9)	F10.0	Lower leg y-axis moment of inertia.

LINE 22F: Segment Moment of Inertia with Respect to Local z-axis (only if IMAN = 2 or 3)

DESCRIPTION: Moments of inertia with respect to z-axis for segments 1, 2, 3, 4, 5, 8, and 9 (lb-in.-sec^2).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CIZ(1)	CIZ(2)	CIZ(3)	CIZ(4)	CIZ(5)	CIZ(8)	CIZ(9)

FIELD	FORMAT	CONTENTS
CIZ(1)	F10.0	Lower torso z-axis moment of inertia.
CIZ(2)	F10.0	Upper torso z-axis moment of inertia.
CIZ(3)	F10.0	Head/neck z-axis moment of inertia.
CIZ(4)	F10.0	Upper arm z-axis moment of inertia.
CIZ(5)	F10.0	Lower arm z-axis moment of inertia.
CIZ(8)	F10.0	Upper leg z-axis moment of inertia.
CIZ(9)	F10.0	Lower leg z-axis moment of inertia.

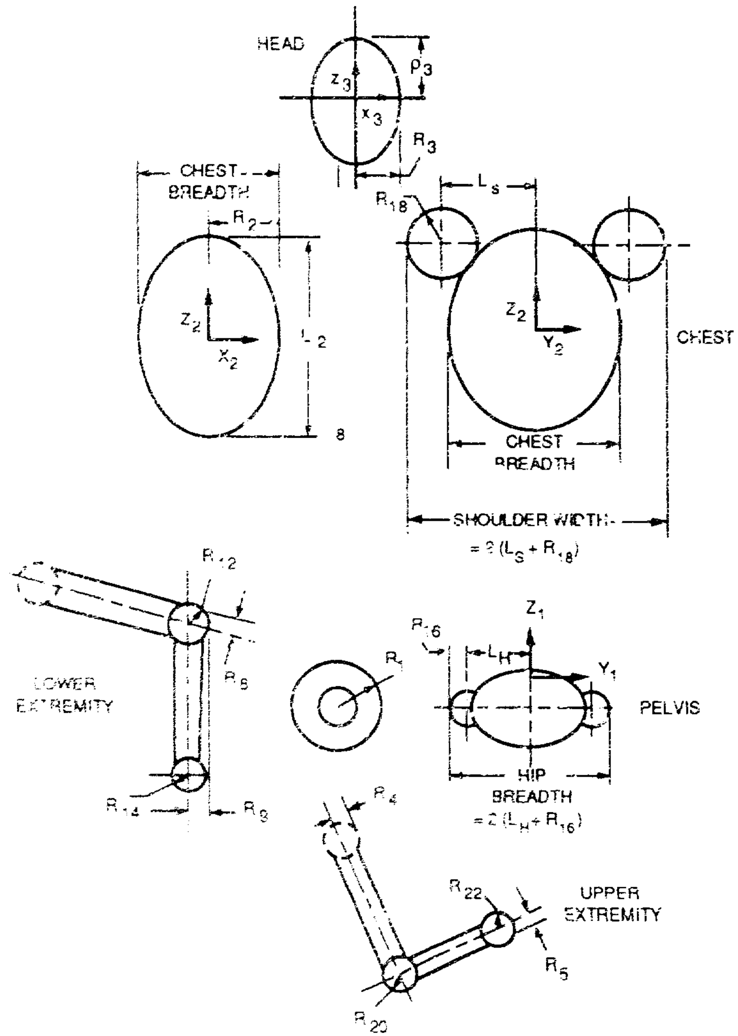
LINE 22G: Contact Surface Radii (only if IMAN = 2 or 3)

DESCRIPTION: Radii of contact surfaces 1, 2, 3, 4, 5, 8, and 9 (in.). (See Figure A-7 and Table A-1 for human occupant.)

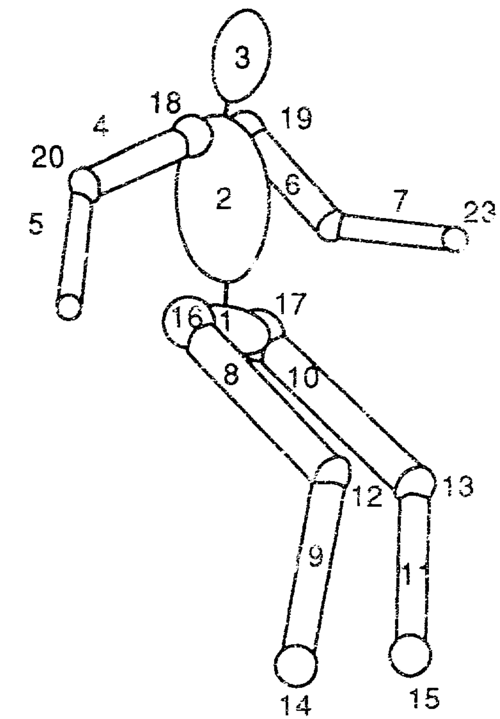
FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XR(1)	XR(2)	XR(3)	XR(4)	XR(5)	XR(8)	XR(9)

FIELD	FORMAT	CONTENTS
XR(1)	F10.0	Radius of lower torso contact surface ellipsoid.
XR(2)	F10.0	Radius of upper torso in mid-saggital plane.
XR(3)	F10.0	Radius of head in mid-saggital plane.
XR(4)	F10.0	Radius of upper arm contact surface cylinder.
XR(5)	F10.0	Radius of lower arm contact surface cylinder.
XR(8)	F10.0	Radius of upper leg contact surface cylinder.
XR(9)	F10.0	Radius of lower leg contact surface cylinder.



a) Body contact surface dimensions



a) Contact surface identification

Figure A-7. Body contact surfaces description.

TABLE A-1. STANDARD CONTACT SURFACE DIMENSIONS

Surface	Symbol	Fraction of Stature (R_i/S)	Actual Dimension for 50th-Percentile Human Male (in.)
Pelvis	R_1	0.0579	4.00
Chest	R_2	0.0689	4.76
Head	R_3	0.0485	3.35
Arm	R_4,R_6	0.0263	1.82
Forearm	R_5,R_7	0.0243	1.68
Thigh	R_8,R_{10}	0.0466	3.22
Leg	R_9,R_{11}	0.0344	2.38
Knee	R_{12},R_{13}	0.0373	2.58
Foot	R_{14},R_{15}	0.0405	3.10
Hip	R_{16},R_{17}	0.0515	3.56
Shoulder	R_{18},R_{19}	0.0378	2.61
Elbow	R_{20},R_{21}	0.0268	1.85
Hand	R_{22},R_{23}	0.0339	2.34

LINE 22H: Contact Surface Radii Continued (only if IMAN = 2 or 3)

DESCRIPTION: Radii of contact surfaces 12, 14, 16, 18, 20, and 22 (in.).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XR(12)	XR(14)	XR(16)	XR(18)	XR(20)	XR(22)	

FIELD	FORMAT	CONTENTS
XR(12)	F10.0	Radius of neck contact surface ellipsoid.
XR(14)	F10.0	Radius of foot contact surface sphere.
XR(16)	F10.0	Radius of hip contact surface sphere.
XR(18)	F10.0	Radius of shoulder contact surface sphere.
XR(20)	F10.0	Radius of elbow contact surface sphere.
XR(22)	F10.0	Radius of hand contact surface sphere.

LINE 22I: Spherical Joint and Center of Mass Offset Distances (only if IMAN = 2 or 3)

DESCRIPTION: Distances that spherical joints (shoulder and hip) are laterally offset from the mid-saggital plane, and the anterior offset of the major upper body segment (lower torso, upper torso, and head) center of masses from the spine. (See description of distances in Figure A-6.) Dimensions are in inches.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XLH	XLS	EM(1)	EM(2)	EM(3)		

FIELD	FORMAT	CONTENTS
XLH	F10.0	Lateral distance of center of hip joint from mid-saggital plane.
XLS	F10.0	Lateral distance of shoulder joint from mid-saggital plane.
EM(1)	F10.0	Anterior offset distance of the lower torso center of mass from the spine.
EM(2)	F10.0	Anterior offset distance of the upper torso center of mass from the spine.
EM(3)	F10.0	Anterior offset distance of the head center of mass from the spine.

LINE 22J: Abdomen and Chest Compliance (only if IMAN = 2 or 3)

DESCRIPTION: Estimated force-deflection characteristics (compliance) of occupant chest and abdomen under restraint system loads. The force, F, is computed from cushion deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CABD	BABD	CCHE	BCHE			

FIELD	FORMAT	CONTENTS
CABD	F10.0	Coefficient C for abdomen compliance (lb).
BABD	F10.0	Coefficient B for abdomen compliance (in.$^{-1}$).
CCHE	F10.0	Coefficient C for chest compliance (lb).
BCHE	F10.0	Coefficient B for chest compliance (in.$^{-1}$).

LINE 22K: Axial Stiffness and Damping Properties for Spine and Neck (only if IMAN = 2 or 3)

DESCRIPTION: Axial force-deflection characteristics for the spine and neck beam models and associated axial damping. The force, F, is computed from deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CAXS	BAXS	DMPS	CAXN	BAXN	DMPN	

FIELD	FORMAT	CONTENTS
CAXS	F10.0	Coefficient C in above equation for axial spinal stiffness (lb).
BAXS	F10.0	Coefficient B in above equation for axial spinal stiffness ($in.^{-1}$).
DMPS	F10.0	Axial damping in spine ($lb\text{-}sec\text{-}in.^{-1}$).
CAXN	F10.0	Coefficient C in above equation for axial neck stiffness (lb).
BAXN	F10.0	Coefficient B in above equation for axial neck stiffness ($in.^{-1}$).
DMPN	F10.0	Axial damping in neck ($lb\text{-}sec\text{-}in.^{-1}$).

LINE 22L: Rotational Stiffness and Damping Properties for Spine and Neck (only if IMAN = 2 or 3)

DESCRIPTION: Rotational moment-angle characteristics for the spine and neck beam models and associated rotational damping. The moment, M, is computed from angular deflection, δ, according to $M = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CROT(1)	BROT(1)	XJ(1)	CROT(2)	BROT(2)	XJ(2)	

FIELD	FORMAT	CONTENTS
CROT(1)	F10.0	Coefficient C in above equation for rotational spinal stiffness (in.-lb.).
BROT(1)	F10.0	Coefficient B in above equation for rotational spinal stiffness (rad^{-1}).
XJ(1)	F10.0	Rotational damping in spine (lb-sec).
CROT(2)	F10.0	Coefficient C in above equation for rotational neck stiffness (in.-lb).
BROT(2)	F10.0	Coefficient B in above equation for rotational neck stiffness (rad^{-1}).
XJ(2)	F10.0	Rotational damping in neck (lb-sec).

LINE 23: Seat Geometry

DESCRIPTION: Dimensions of seat model as shown in Figure A-8.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XSEAT	ZSEAT	ANGSP	ANGSB	XLPAN	XWPAN	SBHT
10.0	12.0	8.0	16.0	15.15	20.0	39.0

FIELD	FORMAT	CONTENTS
XSEAT ZSEAT	2F10.0	X- and Z-coordinates (in aircraft-fixed system) of intersection of seat pan and seat back planes under the cushions (in.).
ANGSP ANGSB	2F10.0	Seat pan and seat back angles (in aircraft-fixed system), directions as defined in Figure A-8 (deg).
XLPAN	F10.0	Seat pan length (in.).
XWPAN	F10.0	Seat pan width (in.).
SBHT	F10.0	Seat back height (in.).

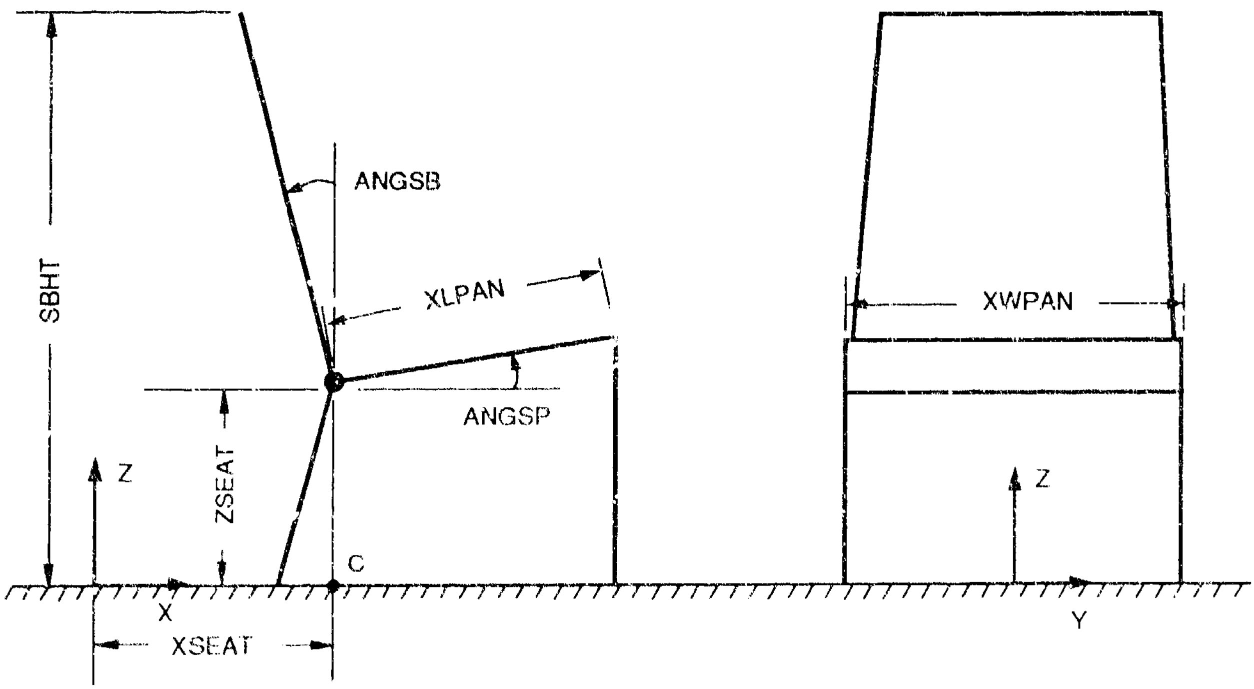


Figure A-8. Rigid seat model geometry

A.1 ENERGY-ABSORBING SEAT INPUT

Lines 24 through 26 provide input for an energy-absorbing seat option, which can be used only if NSEAT = 0 on Line 3. If the stroking seat weight, SEATM, on Line 24 is zero (or blank), this option is not used and any data on Lines 24 through 26 are ignored. If SEATM is nonzero, the energy absorber force-deflection data illustrated in Figure A-9(a) must be provided on Line 25. If the mass moment of inertia of the seat with respect to the Y-axis, YISEAT, is nonzero on Line 24, then moment-rotation data must be provided on Line 26.

If NSEAT = 1, indicating use of the finite element seat model, Lines 24-26 are ignored, and seat data continue with Line 27.

Note: This example uses the finite element seat model, so that Lines 24-26 are blank. However, sample case no. 3 uses the energy-absorbing seat option.

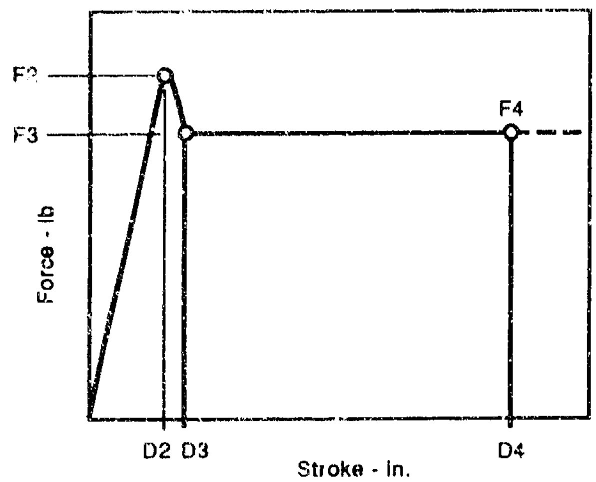
LINE 24: Energy-Absorbing Seat Data

DESCRIPTION: Parameters for the two-degree-of-freedom (seat stroke and rigid-body rotation) energy-absorbing seat model. (See Figure A-9 for a detailed description of the parameters.)

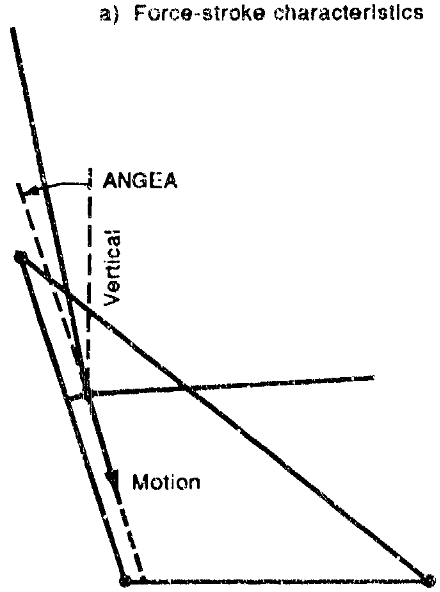
FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SEATM	ANGEA	SUNLOD	SDAMP	YISEAT	RUNLOD	RDAMP

FIELD	FORMAT	CONTENTS
SEATM	F10.0	Weight of movable part of energy-absorbing seat (lb).
ANGEA	F10.0	Stroking angle for guided energy-absorbing seat (deg), see Figure A-9b.
SUNLOD	F10.0	Energy absorber unloading slope (lb/in.).
SDAMP	F10.0	Damping coefficient for the energy absorber (lb-sec/in.).
YISEAT	F10.0	Mass moment of inertia of the seat about a lateral axis through point C (in Figure A-8) with coordinates X = XSEAT, Z = 0 (lb-in.-sec^2).
RUNLOD	F10.0	Unloading slope for rotational deformation of seat (in.-lb/rad).
RDAMP	F10.0	Rotational damping coefficient for the seat (in.-lb-sec).



a) Force-stroke characteristics



b) Geometry

Figure A-9. Energy absorbing seat data.

LINE 25: Energy Absorber Data

DESCRIPTION: Energy absorber force versus deflection (illustrated in Figure A-9a).

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFEA(2)	FFEA(3)	FFEA(4)	DDEA(2)	DDEA(3)	DDEA(4)	

FIELD	FORMAT	CONTENTS
F2 F3 F4	3F10.0	Energy absorber force (lb).
D2 D3 D4	3F10.0	Deflections corresponding to above forces (in.); see Figure A 9a.

LINE 26: Rigid Seat Rotational Stiffness Parameters

DESCRIPTION: Applied moment versus seat rotational angle as shown in Figure A-10.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFRT(2)	FFRT(3)	FFRT(4)	DDRT(2)	DDRT(3)	DDRT(4)	

FIELD	FORMAT	CONTENTS
FFRT(2) FFRT(3) FFRT(4)	3F10.0	Applied moment on rigid seat (in.-lb).
DDRT(2) DDRT(3) DDRT(4)	3F10.0	Angular seat displacement (rad).

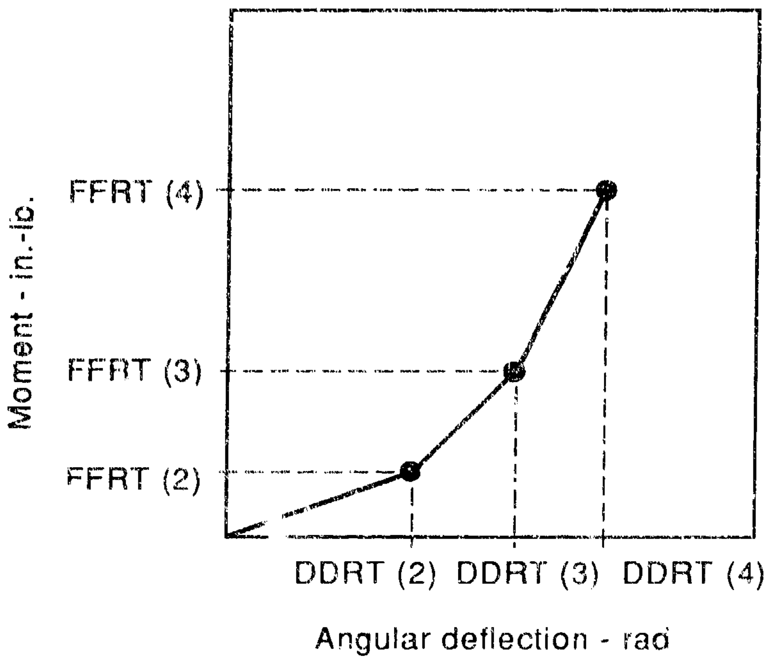


Figure A-10. Rigid seat model rotational stiffness.

A.2 NONRIGID SEAT INPUT

If a nonrigid seat is requested by setting NSEAT = 1 on Line 3, then the input data described on the following lines is required to define the finite element seat model.

LINE 27: Basic Seat Model Data

DESCRIPTION: Control integers for finite element model describing the number of nodes, elements, materials, and cross sections in the model, and the number of plots.

FORMAT AND EXAMPLE:

1		2		3		4	5	6	7
1234567890		1234567890		1234567890		1234567890	1234567890	1234567890	1234567890
NUMNP	NUMEL	NUMAT	NUMDS	NCORD	NSECT	NSPLT			
20	27	2	4	2	2	8			

FIELD	FORMAT	CONTENTS
NUMNP	I5	Number of real nodes.
NUMEL	I5	Number of elements.
NUMAT	I5	Number of materials (up to 8).
NUMDS	I5	Number of displacement-specified node points (at which the aircraft displacement, velocity, and acceleration are applied).
NCORD	I5	Number of inactive beam pointer nodes, which are used to orient the y-axes of beam cross sections. A real node can be used as a pointer node. Also, a single node can be used as a pointer node for more than one beam.
NSECT	I5	Number of different beam cross-section types (up to 10).
NSPLT	I5	Number of requested seat position plots (up to 20).

LINE 28: Miscellaneous Control Flags

DESCRIPTION: Parameters for controlling execution of finite element seat simulation.

FORMAT AND EXAMPLE:

1		2	3	4	5	6	7
1234567890		1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
KNTRL (1)	KNTRL (2)						
5	5						

FIELD	FORMAT	CONTENTS
KNTRL(1)	I5	Maximum number of iterations for convergence within a time step (default is 5).
KNTRL(2)	I5	Number of increments to enforce the floor warping. (See Lines 43 and 44.) A value of 10 is recommended for cases where the floor warping produces plastic and/or large deformations of the seat structure.

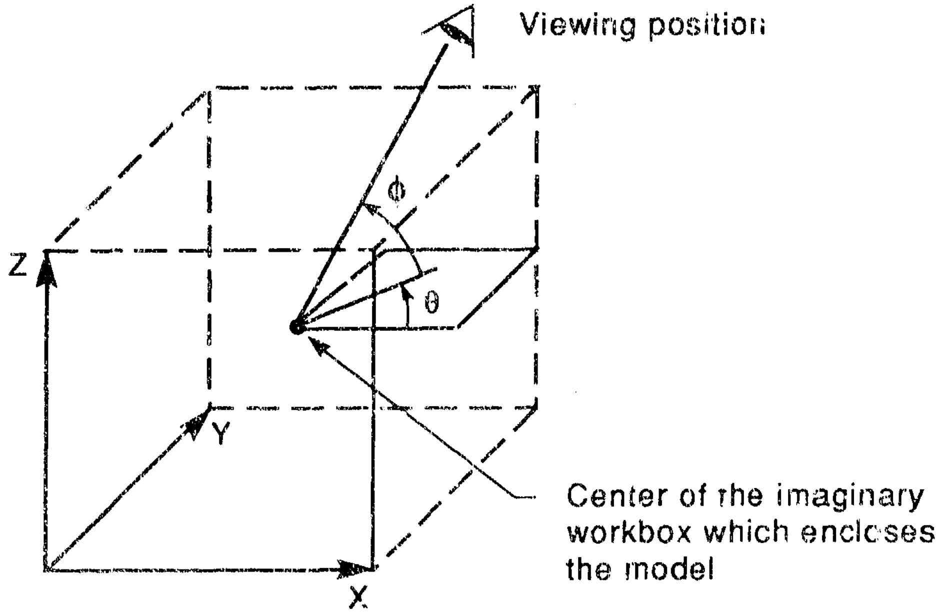
LINE 29: Seat Plot Times and Viewing Angles (number of lines required = NSPLT on Line 27)

DESCRIPTION: Times when seat structure plot data are to be stored on unit 20, which must be saved as a permanent file for subsequent plotting. The elevation and azimuth angles corresponding to each time are illustrated in Figure A-11.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TSPLT	THEPLT	PHIPLT				
0.0	45.0	20.0				
0.025	45.0	20.0				
0.050	45.0	20.0				
0.075	45.0	20.0				
0.100	45.0	20.0				
0.125	45.0	20.0				
0.150	45.0	20.0				
0.175	45.0	20.0				

FIELD	FORMAT	CONTENTS
TSPLT	F10.0	Plot times (sec).
THEPLT	F10.0	Azimuth angle for viewing seat plot (deg).
PHIPLT	F10.0	Elevation angle for viewing seat plot (deg).



θ = Azimuth angle in X-Y plane in degrees ($-180° \leq \theta \leq +180°$)
ϕ = Elevation angle in degrees ($-90° \leq \phi \leq +90°$)

Figure A-11. Angular coordinates for viewing of seat models.

LINE 30: Nodal Output Selection (used only if IOUT(8) > 0)

DESCRIPTION: Node numbers, in pairs, to specify which X, Y, Z displacements are to be printed. (The node numbers are defined on Line 38.)

FORMAT AND EXAMPLE:

1		2		3		4		5		6	7
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890	1234567890
KNODE (1)	KNODE (2)	KNODE (3)	KNODE (4)	KNODE (5)	KNODE (6)	KNODE (7)	KNODE (8)	KNODE (9)	KNODE (10)		
1	20										

FIELD	FORMAT	CONTENTS
KNODE	5(2I5)	Nodal displacements printed for nodes beginning with KNODE(I) through KNODE(I+1), inclusive. Up to 5 pairs of nodes are permitted.

LINE 31: Beam Load and Stress Selection (used only if IOUT(10) > 0)

DESCRIPTION: Element numbers, in pairs, to specify which stresses are to be printed. Maximum and minimum values of stress are printed at both ends of selected beams.

FORMAT AND EXAMPLE:

1		2		3		4		5		6	7
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890	1234567890
KBEAM (1)	KBEAM (2)	KBEAM (3)	KBEAM (4)	KBEAM (5)	KBEAM (6)	KBEAM (7)	KBEAM (8)	KBEAM (9)	KBEAM (10)		
1	27										

FIELD	FORMAT	CONTENTS
KBEAM	5(2I5)	Loads and stresses printed for beam elements beginning with KBEAM(I) through KBEAM(I+1), inclusive. Up to 5 pairs of elements are permitted.

LINE 32: Seat Structure Output Time Interval

DESCRIPTION: Interval at which node and element data indicated on Lines 30 and 31 are to be printed.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
DTSEAT						
0.025						

FIELD	FORMAT	CONTENTS
DTSEAT	F10.0	Time interval in seconds.

LINE 33: Material Type Number

DESCRIPTION: Material type designation number. Repeat group 33 through 35 in sequence NUMAT times, as specified on Line 27, one sequence for each material.

FORMAT AND EXAMPLES:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

MTYP	MAT	
1	2024-T4 AL	

FIELD	FORMAT	CONTENTS
MYTP	I5	Material type designation number. The element data on Line 39 specifies the material type by referring to this number.
MAT	A10	Material type description used as heading for material property output.

LINE 34: Material Properties

DESCRIPTION: Material physical properties as described in Figure A-12.

FORMAT AND EXAMPLE:*

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
E(1)	E(2)	E(3)	E(4)	E(5)	E(6)	E(7)
2.588E-4	10.5E6	44000.	4.9E5		62000.	0.3

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
E(1)	F10.0	Density (lb-sec^2/in.^{4}).
E(2)	F10.0	Modulus of elasticity (lb/in.^{2}).
E(3)	F10.0	First yield stress; S_{y1} (lb/in.^{2}) = 0 if elastic.
E(4)	F10.0	First plastic modulus (lb/in.^{2}) = 0 if elastic.
E(5)	F10.0	Not used.
E(6)	F10.0	Ultimate stress; S_{ult} (lb/in.^{2}) = 0 if elastic.
E(7)	F10.0	Poisson's ratio.

*Example for the first of two groups, determined by NUMAT = 2 on Line 27.

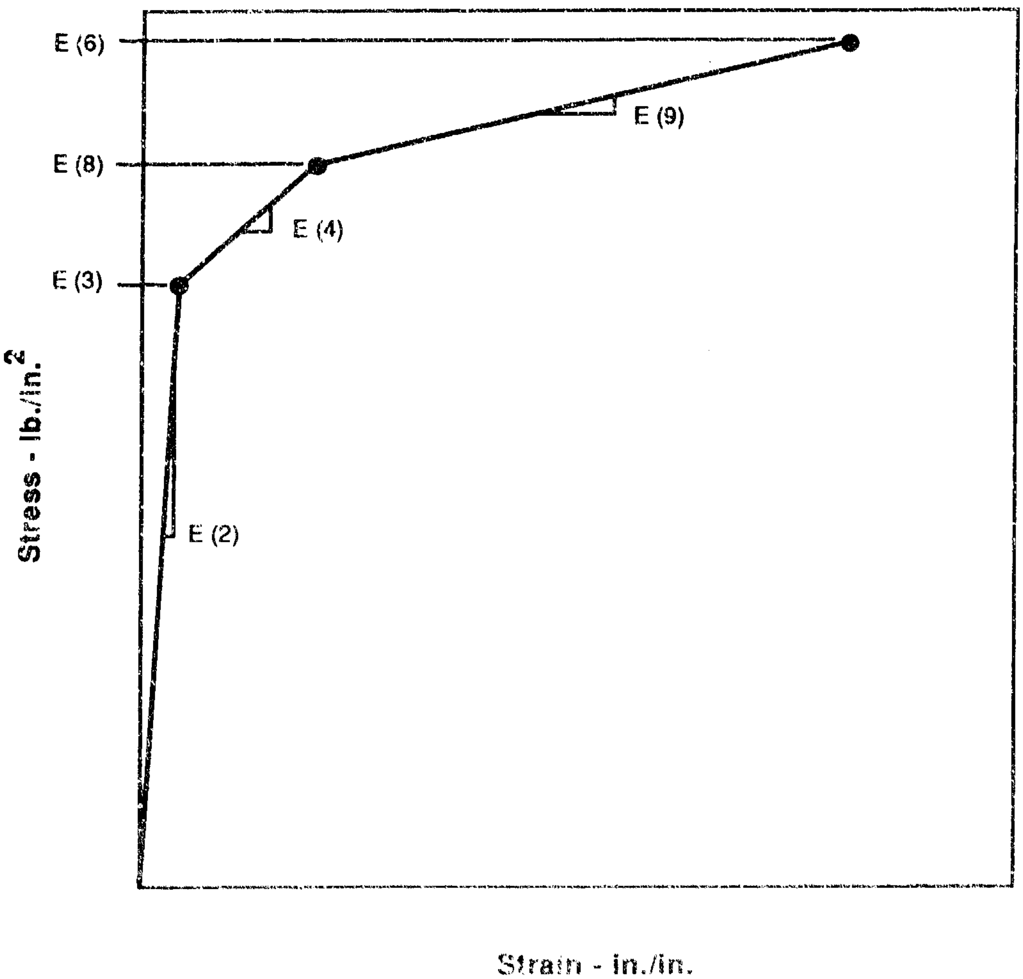


Figure A-12. Idealized stress strain curve.

LINE 35: Material Properties (continued)

DESCRIPTION: Material physical properties as described in Figure A-12.

FORMAT AND EXAMPLE:*

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
E(8)	E(9)	E(10)	E(11)	E(12)		
58000.	62000.	0.0	0.0			

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
E(8)	F10.0	Second yield stress, S_{y2} (lb/in.^{2}).
E(9)	F10.0	Second plastic modulus (lb/in.^{2}).
E(10)	F10.0	Strain-rate coefficient = 0, no strain-rate effect considered.
E(11)	F10.0	Strain-rate exponent = 0, no strain-rate effect considered.
E(12)	F10.0	Explicit moment curvature flag 1, use explicit moment curvature option (plate) 0, ignored explicit moment curvature option (plate).

*Example for the first of two groups determined by NUMAT = 2 on Line 27.

LINE 36: Beam Cross-Section Data

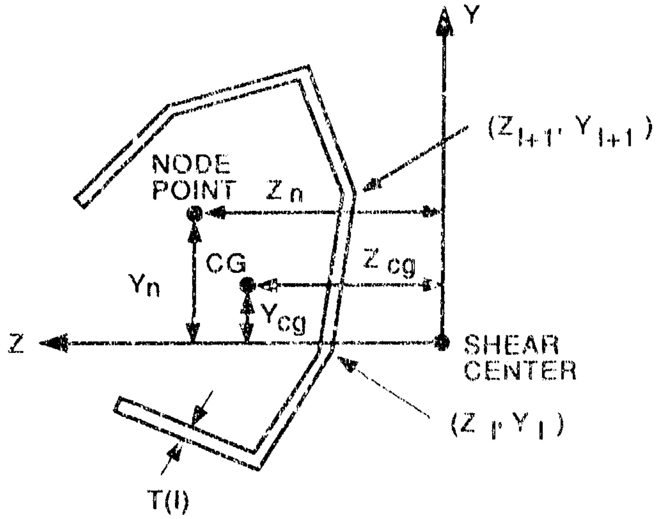
DESCRIPTION: Beam element cross-sectional properties as described in Figure A-13. Repeat group 36 and 37 NSECT times, as specified on Line 27, one sequence for each cross section.

FORMAT AND EXAMPLE:*

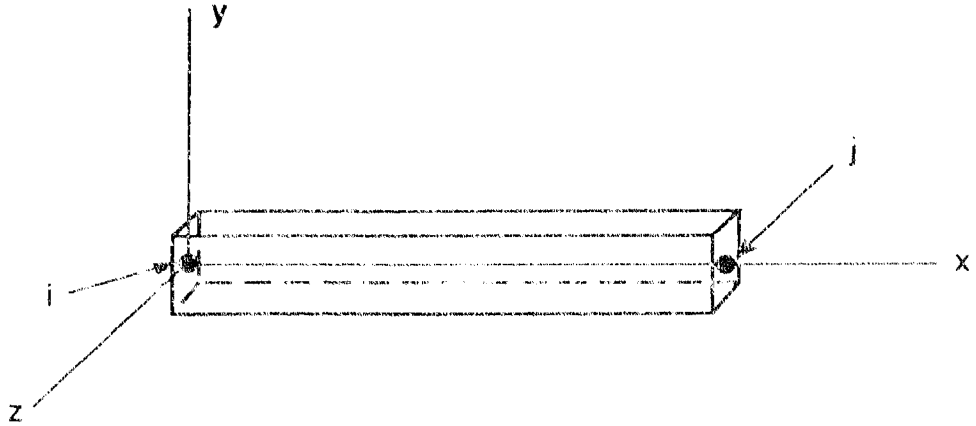
1		2	3	4	5	6	7
1234567890		1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NSEG	KLOS	ABM	FIXX	FIYY	FIZZ		
8	0	0.4347	0.3028	0.1514	0.1514		

FIELD	FORMAT	CONTENTS
NSEG	I5	Number of plate segments in beam cross section.
KLOS	I5	Flag for closed-wall sections KLOS = 0: closed wall KLOS = 1: open wall.
ABM	F10.0	Cross-section area (in.^{2}).
FIXX FIYY FIZZ	3F10.0	Cross-section moments of inertia about x, y, and z principal axes, respectively (in.^{4}). The cross section for each beam element is oriented by specification of a pointer node on the y-axis in the element data on Line 39.

*Example for the first of two groups, determined by NSECT = 2 on Line 27.



a) Cross-section geometry



b) Element coordinate system

Figure A-13 Beam element coordinate system and cross-section geometry.

LINE 37: Beam Cross-Section Data

DESCRIPTION: Beam element cross-sectional dimensions as described in Figure A-13.

NOTES: (1) Repeat Line 37 NSEG + KLOS times, following Line 36.
(2) Repeat the sequence of Lines 36 and 37 NSECT times, as defined on Line 27.

FORMAT AND EXAMPLE:*

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
Y(I)	Z(I)	T(I)				
0.0	0.834	0.083				
-0.590	0.590	0.083				
-0.834	0.0	0.083				
-0.590	-0.590	0.083				
0.0	-0.834	0.083				
0.590	-0.590	0.083				
0.834	0.0	0.083				
0.590	0.590	0.083				

FIELD	FORMAT	CONTENTS
Y(I)	F10.0	Cross-section coordinates of point at beginning of segment I (in.).
Z(I)	F10.0	(See Figure A-13a).
T(I)	F10.0	Segment thickness for segment between points I and I + 1 (in.).

*Example for the first cross section based on NSEG = 8 and KLOS = 0 on Line 36.

LINE 38: Nodal Point Data

DESCRIPTION: Finite element node number and nodal coordinates in global system.

NOTES: Repeat Line 38 NUMNP + NCORD times.

FORMAT AND EXAMPLE:*

1		2	3	4	5	6	7
1234567890		1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
N		XC(N)	YC(N)	ZC(N)			
1		8.0	-10.0	0.0			

FIELD	FORMAT	CONTENTS
N	I5 5X	Node number.
XC(N)	F10.0	X
YC(N)	F10.0	Y coordinates of node point (in.).
ZC(N)	F10.0	Z

*Example for the first of 22 lines, based on NUMNP = 20 and NCORD = 2 on Line 27.

LINE 39: Element Data

DESCRIPTION: Individual element property descriptions.

NOTE: Repeat Line 39 NUMEL times.

FORMAT AND EXAMPLE:*

	1		2		3		4		5		6		7
12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12345	67890
M	NODE (1)	NODE (2)	NODE (3)	NODE (4)	NODE (5)	NODE (6)	NODE (7)	NODE (8)	NODE (9)	NODE (10)	NODE (11)	NODE (12)	NODE (13)
5	2	6			0	2	21	2	2	000	010	000	010

FIELD	FORMAT	CONTENTS FOR BEAM ELEMENT
M	I5	Element number.
NODE(1) NODE(2)	2I5	End nodes.
NODE(3) NODE(4)	2I5	Not used.
NODE(5)	I5	Stiffness flag NODE(5) = 0: Use plastic beam stiffness NODE(5) = 1: Use elastic beam stiffness.
NODE(6)	I5	Cross-section type. The first set of Lines 36 and 37 is assumed to be cross-section type no. 1; the second, no. 2, etc.
NODE(7)	I5	Pointer node for orientation of initial principal beam axis y.
NODE(8)	I5	NODE(8) = 2 for beam element.
NODE(9)	I5	Material type (assumes 1 if left blank).
NODE(10)	I5	Beam-end conditions (forces), at end i, Figure A-13(b) ABC (packed word, right justified) A = Force release in x-direction, if 1 B = Force release in y-direction, if 1 C = Force release in z-direction, if 1.
NODE(11)	I5	Beam-end conditions (moments), at end i, Figure A-13(b) DEF (packed word, right justified) D = Moment release in x-direction, if 1 E = Moment release in y-direction, if 1 F = Moment release in z-direction, if 1.

* Example for the fifth of 27 lines, based on NUMEL = 27 on Line 27

NODE(12)	I5	Beam-end conditions (forces), at end j, Figure A-13(b) OPQ (packed word, right justified) O = Force release in x-direction, if 1 P = Force release in y-direction, if 1 Q = Force release in z-direction, if 1.
NODE(13)	I5	Beam-end conditions (moments), at end j, Figure A-13(b) RST (packed word, right justified) R = Moment release in x-direction, if 1 S = Moment release in y-direction, if 1 T = Moment release in z-direction, if 1.

LINE 40: Seat Pan Nodes

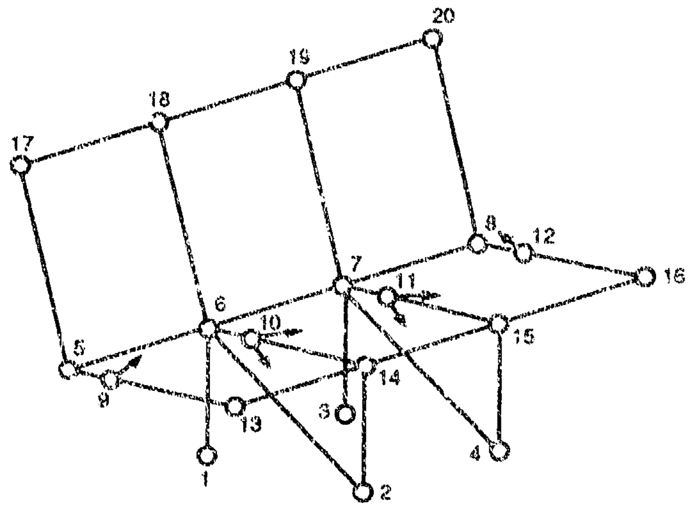
DESCRIPTION: Nodes on which seat cushion loads will be applied, and which are used to define the seat pan outline for the occupant plots.

FORMAT AND EXAMPLE:

	1		2		3		4		5		6	7
1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890
NPAN (1)	NPAN (2)	NPAN (3)	NPAN (4)	NPAN (5)	NPAN (6)	NPAN (7)	NPAN (8)	NPAN (9)	NPAN (10)	NPAN (11)	NPAN (12)	
5	6	13	14	6	7	14	15	7	8	15	16	

FIELD	FORMAT	CONTENTS
NPAN	12I5	Nodes on which seat cushion loads are to be applied, input on rear edge first, then forward edge, and from right to left, as shown in Figure A-14.

Note that in this example node 6 is used as NPAN(2) and NPAN(5), node 14 as NPAN(4) and NPAN(7), node 7 as NPAN(6) and NPAN(9), and node 15 as NPAN(8) and NPAN(11).



COLUMNS	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
LINE 40, NPAN	5	6	13	14	6	7	14	15	7	8	15	16
LINE 41, NBAK	5	6	17	13	6	7	18	19	7	8	19	20
LINE 42, NLBA	9	10	10	11	11	12						

Figure A-14. Illustration of seat pan, back, and lap belt node identification

LINE 41: Seat Back Nodes

DESCRIPTION Nodes on which back cushion loads are to be applied, and which are used to define the seat back outline for the occupant plots.

FORMAT AND EXAMPLE:

<table>
<tr><td colspan="2">1</td><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">4</td><td colspan="2">5</td><td colspan="2">6</td><td colspan="2">7</td></tr>
<tr><td colspan="2">1234567890</td><td colspan="2">1234567890</td><td colspan="2">1234567890</td><td colspan="2">1234567890</td><td colspan="2">1234567890</td><td colspan="2">1234567890</td><td colspan="2">1234567890</td></tr>
<tr><td>NBAK (1)</td><td>NBAK (2)</td><td>NBAK (3)</td><td>NBAK (4)</td><td>NBAK (5)</td><td>NBAK (6)</td><td>NBAK (7)</td><td>NBAK (8)</td><td>NBAK (9)</td><td>NBAK (10)</td><td>NBAK (11)</td><td>NBAK (12)</td><td colspan="2"></td></tr>
<tr><td>5</td><td>6</td><td>17</td><td>18</td><td>6</td><td>7</td><td>18</td><td>19</td><td>7</td><td>8</td><td>19</td><td>20</td><td colspan="2"></td></tr>
</table>

FIELD	FORMAT	CONTENTS
NBAK	12I5	Nodes on which back cushion loads are to be applied, input on lower edge first, then top, and from right to left, as shown in Figure A-14.

Note that in this example node 6 is used as NBAK(2) and NBAK(5), node 7 as NBAK(6) and NBAK(9), etc.

LINE 42: Restraint System Anchor Point Nodes (NOCC lines)

DESCRIPTION: Nodal points on seat structure to which restraint system is attached as shown in Figure A-14.

FORMAT AND EXAMPLE:

1		2		3	4	5	6	7
12345	67890	12345	67890	1234567890	1234567890	1234567890	1234567890	1234567890
NLBA (1)	NLBA (2)	NSHA (1)	NSHA (2)	NTD				
9	10							
10	11							
11	12							

FIELD	FORMAT	CONTENTS
NLBA	2I5	Seat structure nodes at which lap belt is attached, right side first, then left, as shown in Figure A-14. Not used if lap belt is attached to aircraft floor rather than to the seat.
NSHA	2I5	Seat structure nodes at which shoulder harness load is to be applied (one node), or distributed (two nodes). Leave blank if shoulder harness is not used or not attached to seat.
NTD	I5	Seat structure node at which lap belt tiedown strap load is to be applied. Leave blank if tiedown strap is not used.

Note that for this example node 10 is used as both NLBA(2) for passenger 1 and NLBA(1) for passenger 2, and node 11 is used as both NLBA(2) for passenger 2 and NLBA(1) for passenger 3, as common points of attachment for lap-belts are usually found on transport seats. Also, in this example no shoulder harness is used.

LINE 43: Node Constraint Data

DESCRIPTION: Packed (encoded) word for each nodal point that is constrained in at least one degree of freedom.

NOTE:
(1) Repeat Line 43 NUMDS times. Omit if NUMDS = 0.
(2) If any of the displacement/rotation codes is set to 2 to enforce floor warping, include Line 44 immediately following the corresponding Line 43 data.

FORMAT AND EXAMPLE:*

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NODDIS						
2112001						

FIELD	FORMAT	CONTENTS
NODDIS	I10	Packed word - NABCDEF (right justified) N = Node number A = Displacement code in X direction B = Displacement code in Y direction C = Displacement code in Z direction D = Rotation code in X direction E = Rotation code in Y direction F = Rotation code in Z direction A, B, C, D, E, or F = 0, no constraint = 1, constrained for zero displacement/rotation = 2, constrained for floor warp displacement/rotation.

*Example for the second of five lines, based on NUMDS = 1 on Line ??, and displacement/rotation codes set to 2 on Line 13.

LINE 44: Floor Warp Data

DESCRIPTION: Floor warp displacement/rotation.

NOTE: (1) Repeat Line 44 for each displacement/rotation code set to 2 in Line 43, in the order from displacement in X-direction to rotation in Z-direction.
(2) Rotations are input in radians; displacements, in inches.

FORMAT AND EXAMPLE:*

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FWARP						
-0.5						

FIELD	FORMAT	CONTENTS
FWARP	F10.0	Floor warp displacement/rotation.

*Example for the third of five lines based on NUMDS = 4 on Line [illegible] and displacement/rotation codes set to 2 on Line 43.

A.3 SECONDARY IMPACT INPUT

If contact with the seat back is to be simulated (by IOUT(4) = 1 or 2), the following lines of input data are required to describe the surfaces on the seat back (only with NSEAT = 0 on Line 3). These lines would directly follow Line 26 (with the finite element seat model data omitted).

LINE 45: Seat Back Contact Surface Dimensions

DESCRIPTION: Dimensions of contact surfaces on seat back, as illustrated in Figure A-15.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TTT	WTT	HTT	TAR	WAR	HAR	XLAR

FIELD	FORMAT	CONTENTS
TTT	F10.0	Distance from top of seat back to top edge of stowed tray table (in.).
WTT	F10.0	Width of tray tal (in.).
HTT	F10.0	Height of tray table (in.).
TAR	F10.0	Distance from top of seat back to top of armrest (in.).
WAR	F10.0	Width of armrest (in.).
HAR	F10.0	Height of armrest (in.).
XLAR	F10.0	Length of armrest (in.).

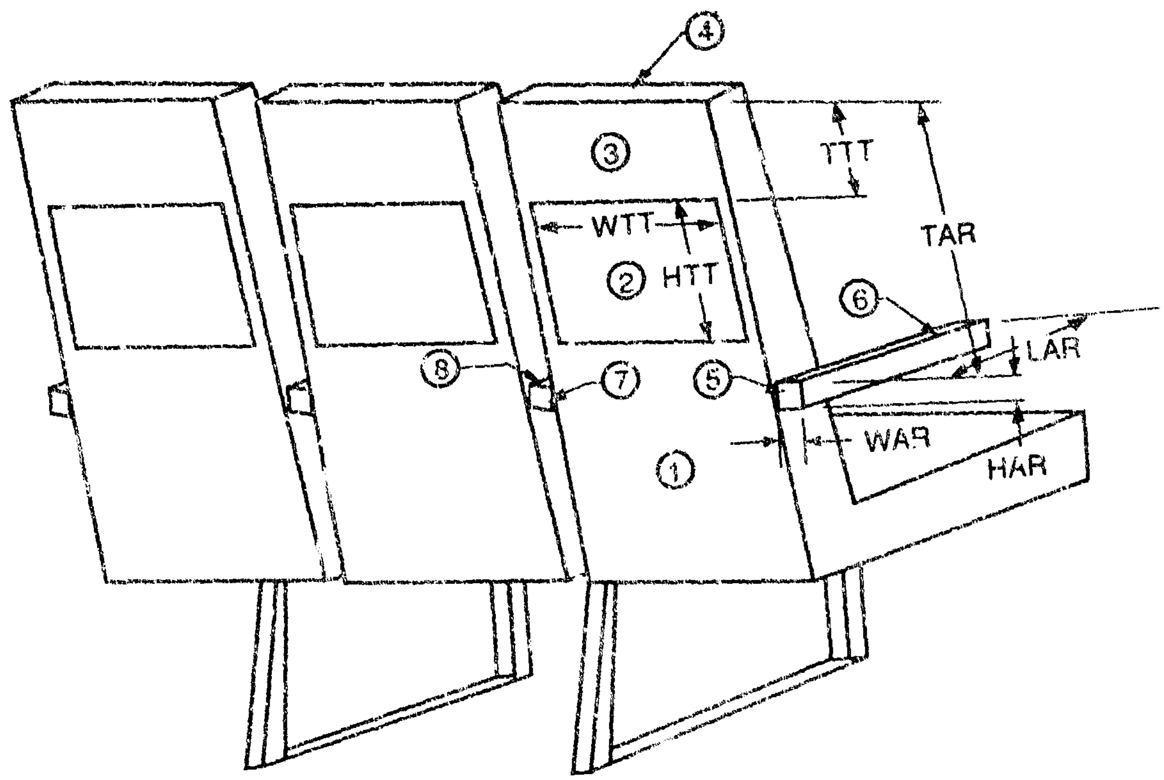


Figure A-15. Seat back contact surfaces.

LINE 46-48: Seat Back Force-Deformation Properties

DESCRIPTION: Force-deflection characteristics and damping for seat back surfaces. The force is computed from deflection, δ, according to $F = C(e^{B\delta} - 1)$.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
CCON(1)	BCON(1)	DCON(1)				
CCON(2)	BCON(2)	DCON(2)				
CCON(3)	BCON(3)	DCON(3)				

FIELD	FORMAT	CONTENTS
CCON	F10.0	Coefficient C in above equation (lb).
BCON	F10.0	Coefficient B ($in.^{-1}$).
DCON	F10.0	Damping coefficient at zero load (lb-sec/in.).

Three lines of data are input in the above format. The first (46) applies to the cushion surfaces (1, 3, and 4, in Figure A-15). The second line (47) applies to the tray table (2 in Figure A-15). The third refers to the armrest surfaces (5-8 in Figure A-15).

LINE 49: Seat Back Weight and Row Pitch

DESCRIPTION: Weight of the movable seat back for use in the breakover model, damping coefficient for seat back breakover, and seat row pitch.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
BKWT	DPBO	SPITCH				

FIELD	FORMAT	CONTENTS
BKWT	F10.0	Seat back weight (lb).
DPBO	F10.0	Damping coefficient (in.-lb-sec).
SPITCH	F10.0	Seat row pitch (in.).

LINE 50: Seat Back Breakover Resistance

DESCRIPTION: Seat back breakover moment versus rotatioin angle, similar to that shown in Figure A-10.

FORMAT AND EXAMPLE:

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
FFBO(2)	FFBO(3)	FFBO(4)	DDBO(2)	DDBO(3)	DDBO(4)	

FIELD	FORMAT	CONTENTS
FFBO(2) FFBO(3) FFBO(4)	3F10.0	Resisting moment of seat back (in.-lb).
DDBO(2) DDBO(3) DDBO(4)	3F10.0	Angular displacement of seat back (rad.).

APPENDIX B

EXAMPLES OF OCCUPANT CHARACTERISTICS AND MATERIAL PROPERTIES

A significant problem encountered in mathematically modeling a physical system lies in determination of system characteristics and properties. In this appendix are presented examples of the following:

- Occupant dimensions and characteristics.
- Restraint system webbing load-elongation characteristics.
- Cushion load-deflection characteristics.
- Structural material stress-strain characteristics.

The characteristics and properties contained in this appendix are, of course, not intended to be all inclusive, but rather are intended to provide the program user with examples that may aid in setting up new input cases.

B.1 OCCUPANT MODELING CHARACTERISTICS

As described in Chapter 2, dimensions and inertial properties for two standard occupants, a 50th-percentile civilian male and a 50th-percentile anthropomorphic (Part 572) dummy, are included within the program. If a nonstandard occupant is desired, additional data must be provided on Lines 22A through 22L. The format for nonstandard occupant data is displayed in Figure B-1, and parameters are defined on pages A-34 through A-49. In Figure B-2 are presented the properties that are used in the program for the standard (Part 572 50th-percentile) dummy occupant. Figure B-3 presents a set of data for a 95th-percentile dummy, which have simply been scaled from the 50th-percentile data. The use of this scaling method is not suggested if measured properties can be obtained; however, to complete a partial set of properties or obtain a quick estimate of the solution, use of the scaling approach can be justified.

The scaling method is based on multiplying the 50th-percentile properties by the appropriate nondimensional scaling factor. All properties with length dimensions are multiplied by the ratio of nonstandard occupant sitting height to 50th-percentile sitting height. In this example:

$$\text{Length Factor} = \frac{\text{95th \% Sitting Height}}{\text{50th \% Sitting Height}} = \frac{37.8 \text{ in}}{35.7 \text{ in}} = 1.06$$

Similarly, occupant properties based on weight are scaled by the occupant weight ratio, i.e.:

$$\text{Weight Factor} = \frac{\text{95th \% Weight}}{\text{50th \% Weight}} = \frac{212 \text{ lb}}{164 \text{ lb}} = 1.29$$

The factor for scaling moments of inertia was derived from a dimensional analysis for the variables involved. The resulting scaling factor is:

$$\text{Moment of Inertia Factor} = \frac{(\text{95th \% Weight})^2 \, (\text{95th \% Sitting Height})^2}{(\text{50th \% Weight})^2 \, (\text{50th \% Sitting Height})^2} = 1.45$$

Since there is no valid basis for scaling stiffnesses, the 50th-percentile spine and neck stiffness properties were retained.

B.2 WEBBING LOAD-ELONGATION CHARACTERISTICS

Figures B-4 and B-5 present static load-elongation characteristics for several types of nylon and polyester restraint system webbing, respectively. Very little dynamic data for webbing deformation exist; however, Figures B-6 and B-7 present some dynamic results taken from reference B.1.

The damping coefficients for the restraint components are based on three assumptions: that the webbing damping coefficient is not a function of strain condition, that it is independent of strain rate, and that the Voigt-Kelvin model (shown in Figure B-8) can be used to represent the webbing.

The first assumption allows the use of a linear approximation to the static and dynamic load-strain curves for the webbing material. The single slope approximation should be the best estimate for the expected range of webbing loads, and not for the entire curve. The second assumption indicates that the damping coefficient will be applicable to all possible strain rates encountered in the simulation. The accuracy of the damping coefficient can be maximized by basing the calculated value on dynamic webbing test data measured at an applicable strain rate. The procedure for calculating the damping coefficient for nylon webbing (MIL-W-4088 TYPE VII) is given below.

The static load-elongation curve for the nylon webbing sample is shown in Figure B-9. A linear approximation to this curve is 11,000 lb/in./in. over the expected load range of 0 to 2000 lb. The slope of the dynamic test data, measured at a strain rate of 40.9 in./in./sec, is approximated as 26,000 lb/in./in. Based on the assumption of a parallel spring-damper model, the dynamic load at any elongation value must be equal to the static load plus the damper force, i.e.,

$$\begin{aligned} P_{DYNAMIC} &= P_{STATIC} + P_{DAMPING} \\ &= K\varepsilon + C\dot{\varepsilon} \end{aligned} \qquad \text{(B-1)}$$

Where:

- K is slope of the load-strain curve (lb/in./in.)
- C is the damping coefficient (lb-sec/in./in.)
- ε is the strain (in./in.)
- $\dot{\varepsilon}$ is the strain rate (in./in./sec)

Therefore, the damping coefficient can be calculated using

$$C = \frac{P_{DYNAMIC} - K\varepsilon}{\dot{\varepsilon}} \qquad \text{(B-2)}$$

Using as a representative point a dynamic load of 2000 lb and 0.0825 in./in. strain, the damping coefficient for the nylon webbing is calculated as

$$C = \frac{2000 \text{ lb} - (11{,}000 \text{ lb/in./in})(0.0825 \text{ in./in.})}{40.9 \text{ in./in./sec}}$$

$$= 26.7 \frac{\text{lb - sec}}{\text{in./in.}}$$

B.3 CUSHION LOAD-DEFLECTION-CHARACTERISTICS

The seat cushion represented in Program SOM-LA/SOM-TA accounts for the stiffness and damping properties of the cushion combined with the occupant buttocks. This modeling approach is desirable in order to avoid the numerical problems associated with springs in a series configuration. An experiment was performed to develop load-deflection properties for representative cushions. The experiment consisted of applying a known static load in the downward direction to the lower torso segment of an Alderson VIP-95 dummy. This downward load, which was applied at the spine base plate, caused both the buttocks and cushion to deform. The deflections of the combined system, buttocks and cushion, and the buttocks separately were measured for each applied load.

A description of the cushions used in load-deflection tests is given in Table B-1. The cushions were selected to provide a spectrum of the possible cushion configurations that the user may select. Combined load-deflection curves for the VIP-95 buttocks and cushions are presented in Figures B-10 through B-14. The form that the load-deflection curves take is a linear slope followed by an exponential stiffening as the cushion and occupant "bottom out." These curves can be approximated by an expression of the form:

$$F = C(e^{B\delta} - 1) \qquad \text{(B-3)}$$

Representing the load-deflection curves with a smooth function alleviates a convergence problem encountered previously with the numerical integration around the slope-change points of a piecewise, linear representation. The exponential representation of the five load-deflection curves, developed with a least-squares approximation routine, is presented as the dashed line in each figure. Also presented in this section are the separate load-deflection curves (Figure B-15) for the Alderson VIP-95 dummy buttocks when tested with each of the five cushion types. This is presented for the user who may want to synthesize a combined load-deflection curve by adding the desired cushion properties determined under a rigid indenter to an average deflection curve for the dummy buttocks. The indenter should be configured like the dummy.

B.4 STRUCTURAL MATERIAL STRESS-STRAIN CURVES

Figures B-16 through B-20 present approximated stress-strain curves for three steels and two aluminum alloys. From each of these curves, six characteristics are provided as input to the finite element seat model.

TABLE B-1. TYPE DESIGNATION AND DESCRIPTION OF CUSHIONS FOR LOAD-DEFLECTION CURVES

Type Number	Description
1	Contoured, multilayered cushion designed to minimize occupant rebound in a crash situation.
2	Contoured, rigid foam cushion designed for negligible deflection.
3	Contoured furniture foam cushion approximately 1.5 in. thick (undeformed) over buttock contact area.
4	Furniture foam slab, 1.2 lb/ft^3 density, approximately 3.0 in. thick (undeformed).
5	Furniture foam slab, 1.4 lb/ft^3 density, approximately 3.0 in. thick (undeformed).

B.5 REFERENCES

B.1. G. Kourouklis, J.L. Glancy, and S.P. Desjardins, The Design, Development, and Testing of an Aircraft Restraint System for Army Aircraft, USAAMRDL Technical Report 72-26, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, June 1971, AD 746631.

1	2	3	4	5	6	7
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
SPL	XL(3)	XL(4)	XL(5)	XL(8)	XL(9)	
RHO(1)	RHO(2)	RHO(3)	RHO(4)	RHO(5)	RHO(8)	RHO(9)
SW(1)	SW(2)	SW(3)	SW(4)	SW(5)	SW(8)	SW(9)
CIX(1)	CIX(2)	CIX(3)	CIX(4)	CIX(5)	CIX(8)	CIX(9)
CIY(1)	CIY(2)	CIY(3)	CIY(4)	CIY(5)	CIY(8)	CIY(9)
CIZ(1)	CIZ(2)	CIZ(3)	CIZ(4)	CIZ(5)	CIZ(8)	CIZ(9)
XR(1)	XR(2)	XR(3)	XR(4)	XR(5)	XR(8)	XR(9)
XR(12)	XR(14)	XR(16)	XR(18)	XR(20)	XR(22)	
XLH	XLS	EM(1)	EM(2)	EM(3)		
CABD	BABD	CCHE	BCHE			
CAXS	BAXS	DMPS	CAXN	BAXN	DMPN	
CROT(1)	BROT(1)	XJ(1)	CROT(2)	BROT(2)	XJ(2)	

Figure B-1. Nonstandard occupant data format.

10.85	8.35	11.3	13.3	16.5	18.0	
4.67	6.55	6.33	4.72	6.26	8.35	10.96
34.6	36.0	12.1	4.85	4.85	21.7	9.49
2.32	2.18	0.275	0.132	0.017	0.127	0.994
0.760	0.926	0.266	0.135	0.185	1.22	0.994
2.32	1.70	0.233	0.022	0.195	0.873	0.505
4.50	4.50	3.44	1.95	1.85	3.10	2.30
2.30	1.60	3.56	2.61	1.85	2.34	
3.70	6.34	0.20	0.20	2.00		
2000.	0.050	2000.	0.380			
6000.	.238	1.0	3240.	0.270	1.0	
375.	1.49	150.	375.	1.49	30.0	

Figure B-2. Data for 50th-percentile standard dummy.

11.50	8.85	11.98	14.10	17.49	19.08	
4.95	6.94	6.71	5.00	6.64	8.85	11.62
44.6	46.4	15.6	6.26	6.26	28.0	12.2
3.36	3.16	0.399	0.191	0.025	0.134	1.44
1.10	1.34	0.386	0.196	0.268	1.77	1.44
3.36	2.47	0.338	0.032	0.283	1.27	0.732
4.77	4.77	3.65	2.07	1.96	3.29	2.44
2.44	1.70	3.77	2.77	1.96	2.48	
3.92	6.72	0.21	0.21	2.12		
2000.	0.050	2000.	0.380			
6000.	0.238	1.0	3240.	0.270	1.0	
375.	1.49	150.	375.	1.49	30.0	

Figure B-3. Data for 95th percentile dummy.

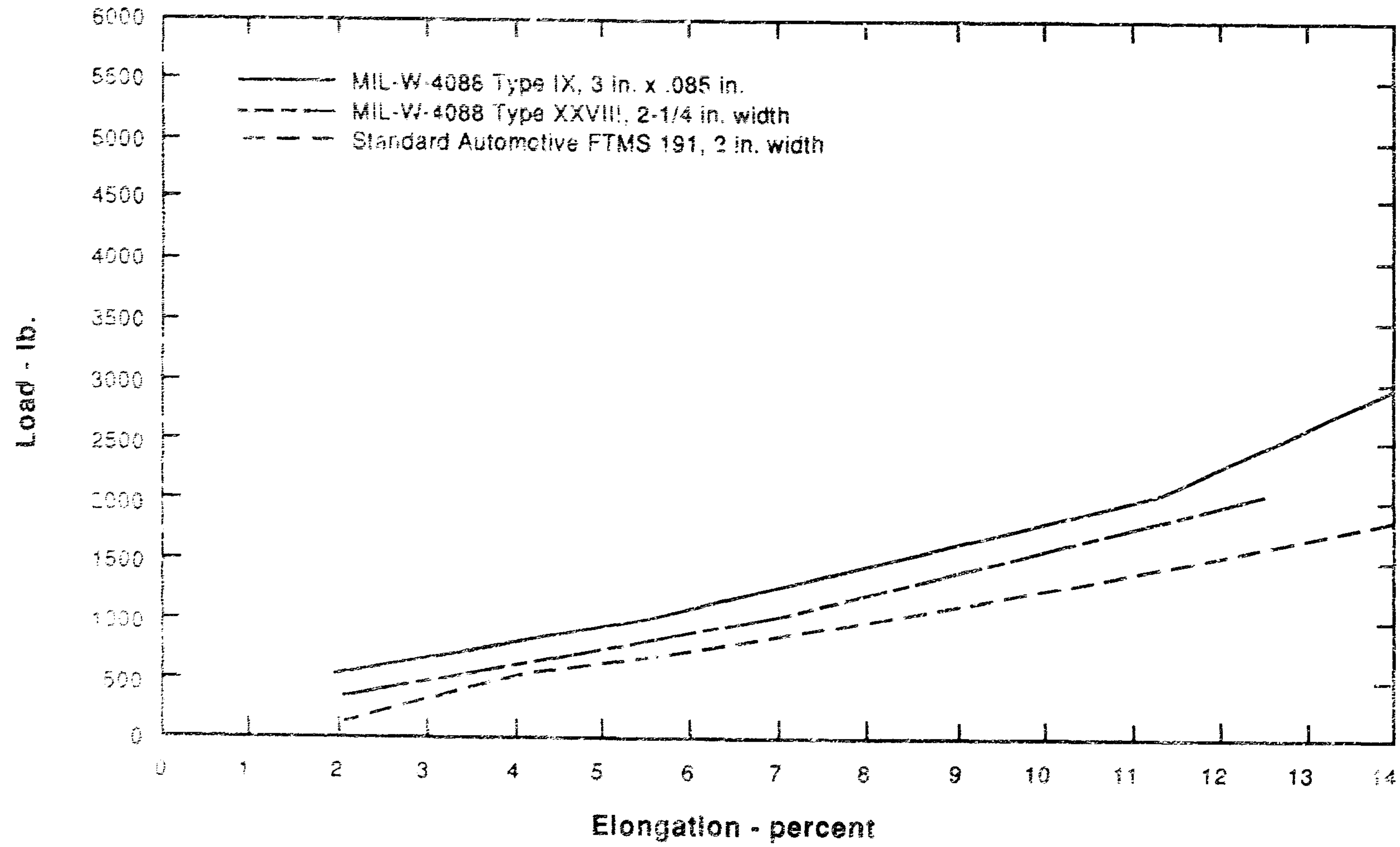


Figure B-4. Load-elongation characteristics for nylon webbing.

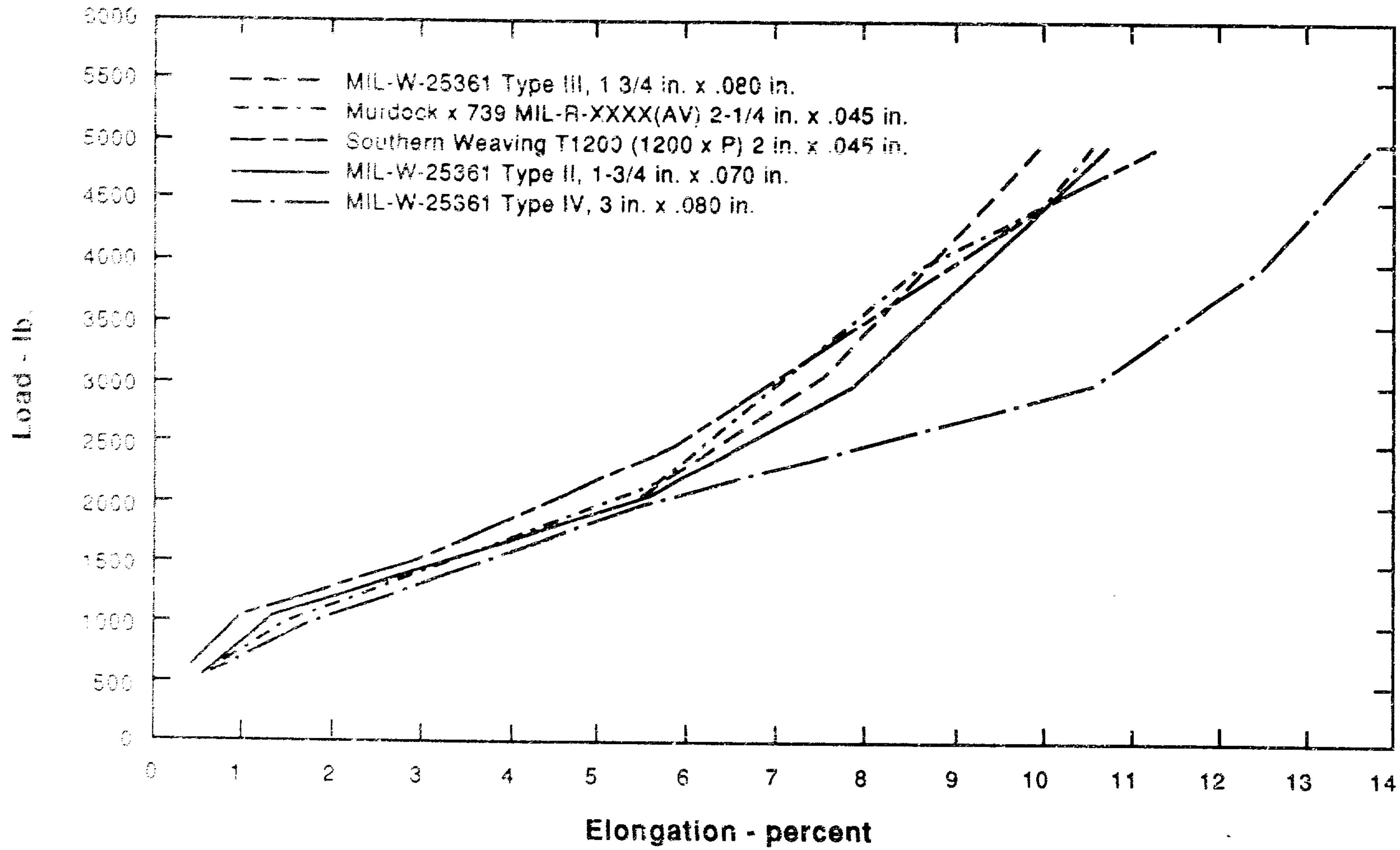


Figure B-5. Load-elongation characteristics for polyester webbing.

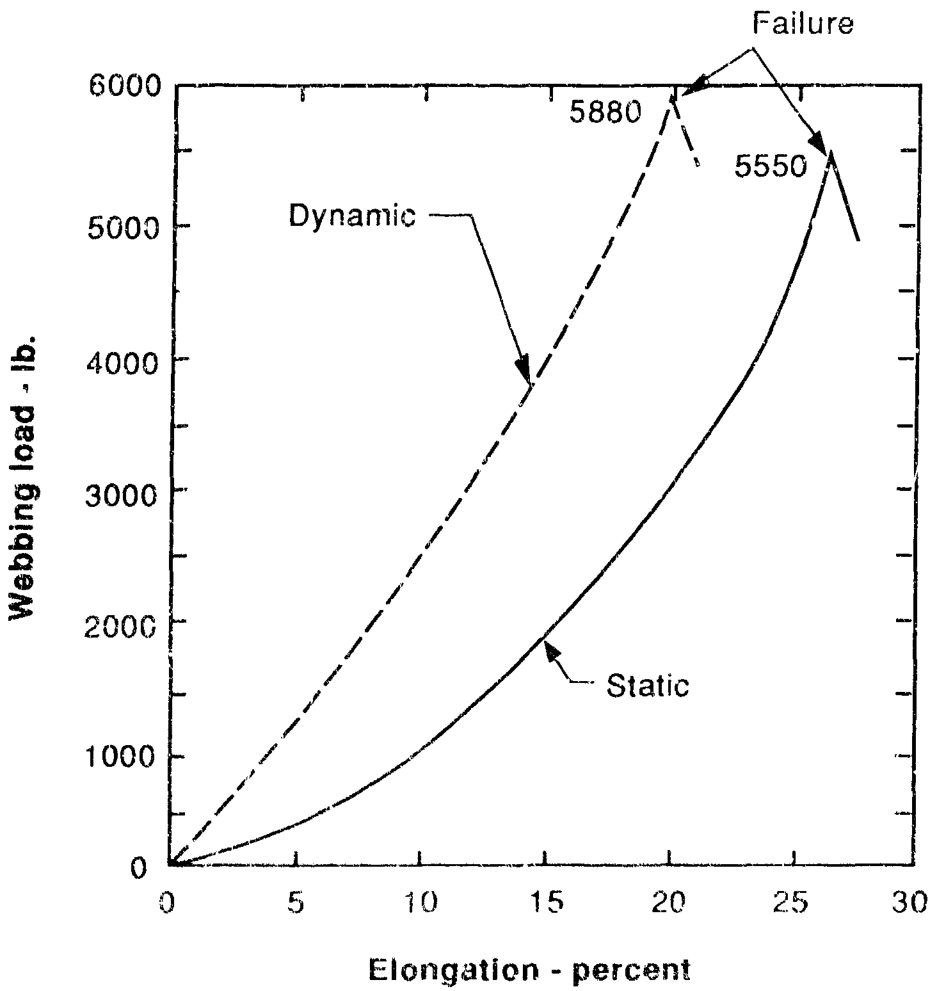


Figure B-6. Load-strain curves for MIL-W-4088 (Type VII) nylon webbing for static and rapid loading rates (from reference B-1).

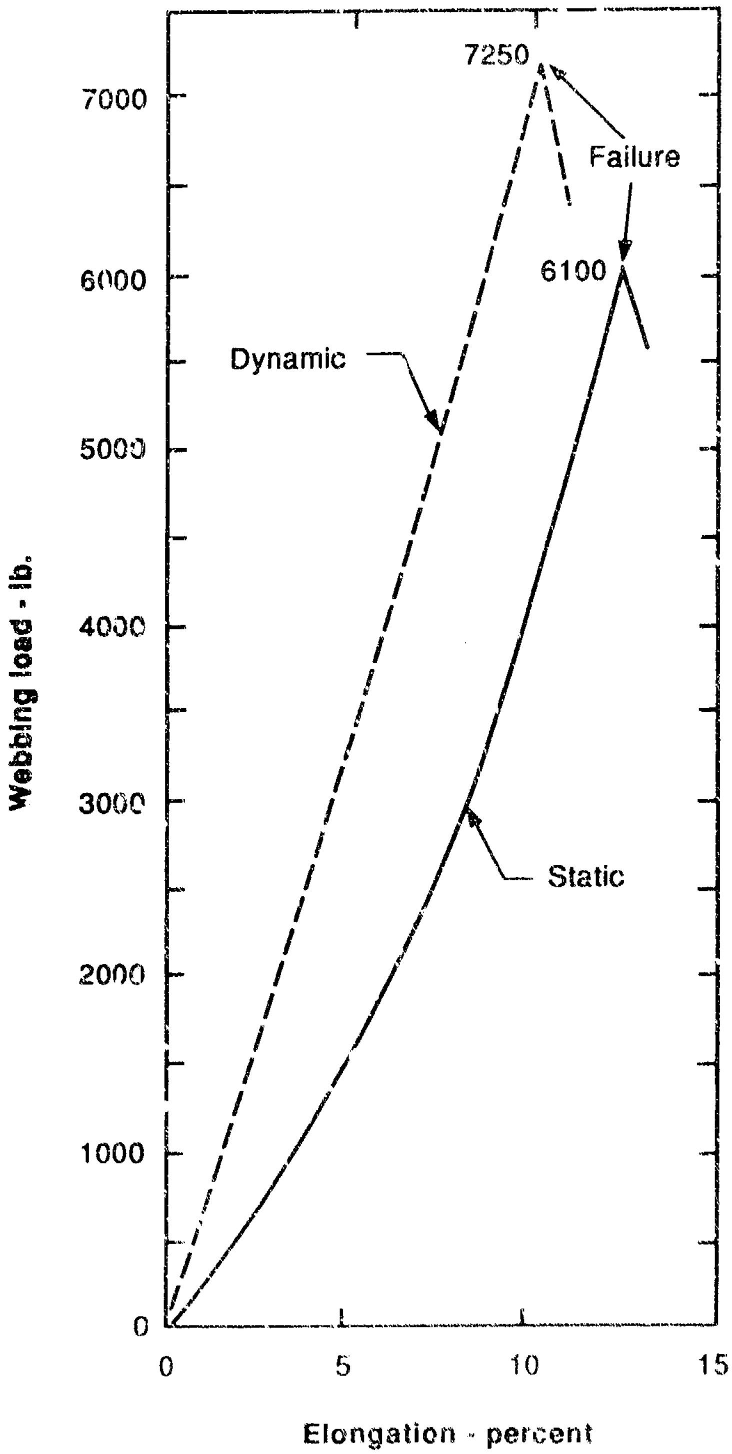


Figure B-7. Load strain curves for MIL-W-25361 (Type II) polyester webbing for static and rapid loading rates (from reference B-1).

K (lb/in.in.)

C (lb-sec/in./in.)

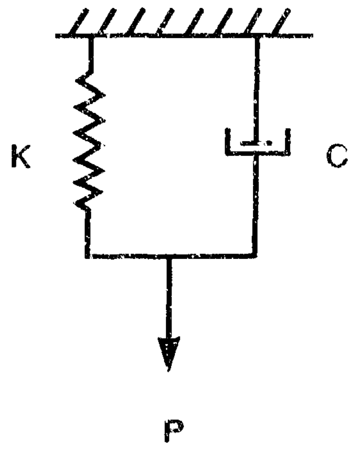


Figure B-8. Voigt-Kelvin model of restrain + system webbing.

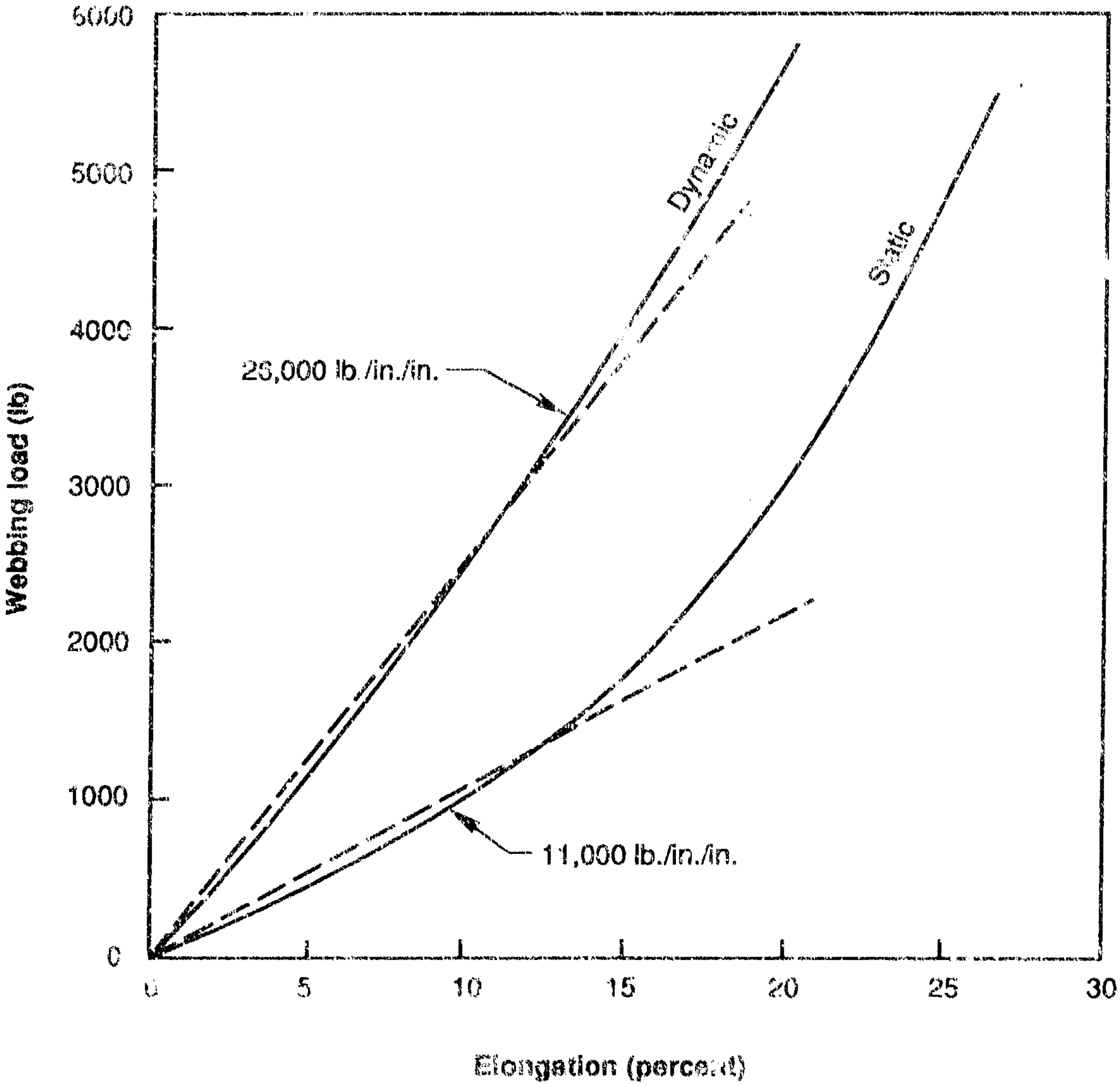


Figure 8-9. Stress-strain curves for MIL-W-4088 (Type VII) nylon webbing for static and rapid loading rates with linear approximations.

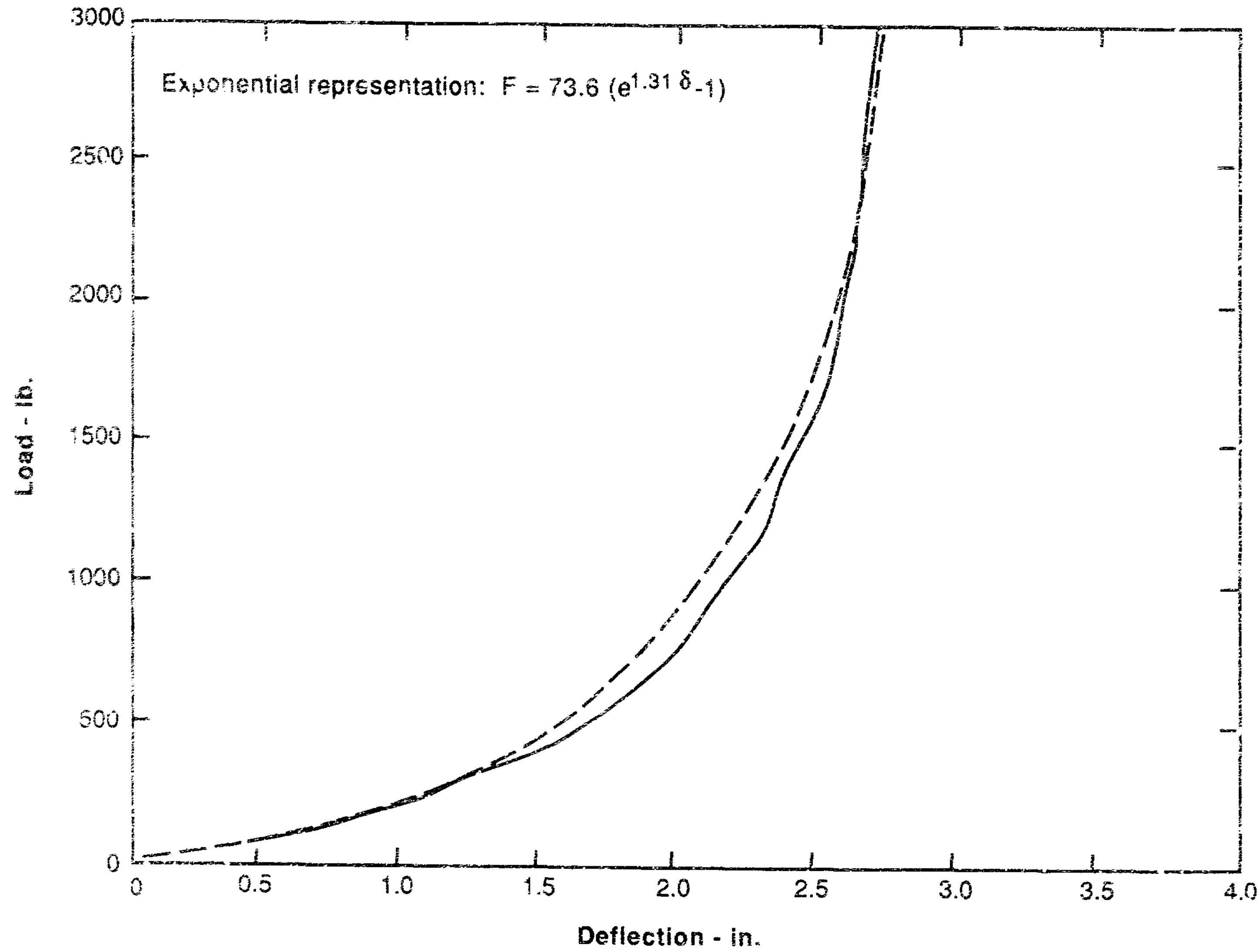


Figure B-10. Combined load-deflection curve and exponential representation for Type 1 cushion and VIP-95 dummy pelvis and buttocks.

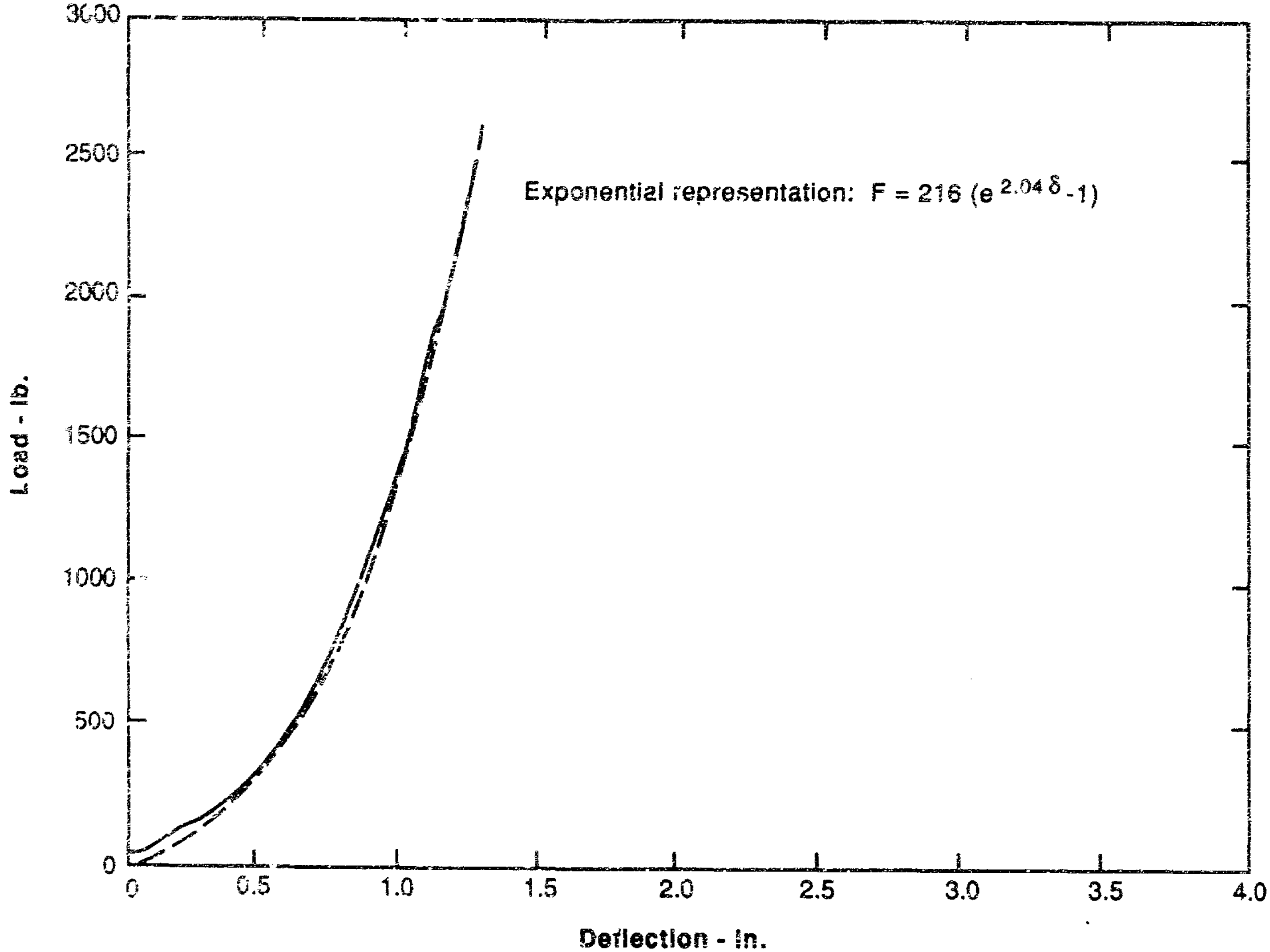


Figure B-11. Combined load-deflection curve and exponential representation for Type 2 cushion and VIP-95 dummy pelvis and buttocks.

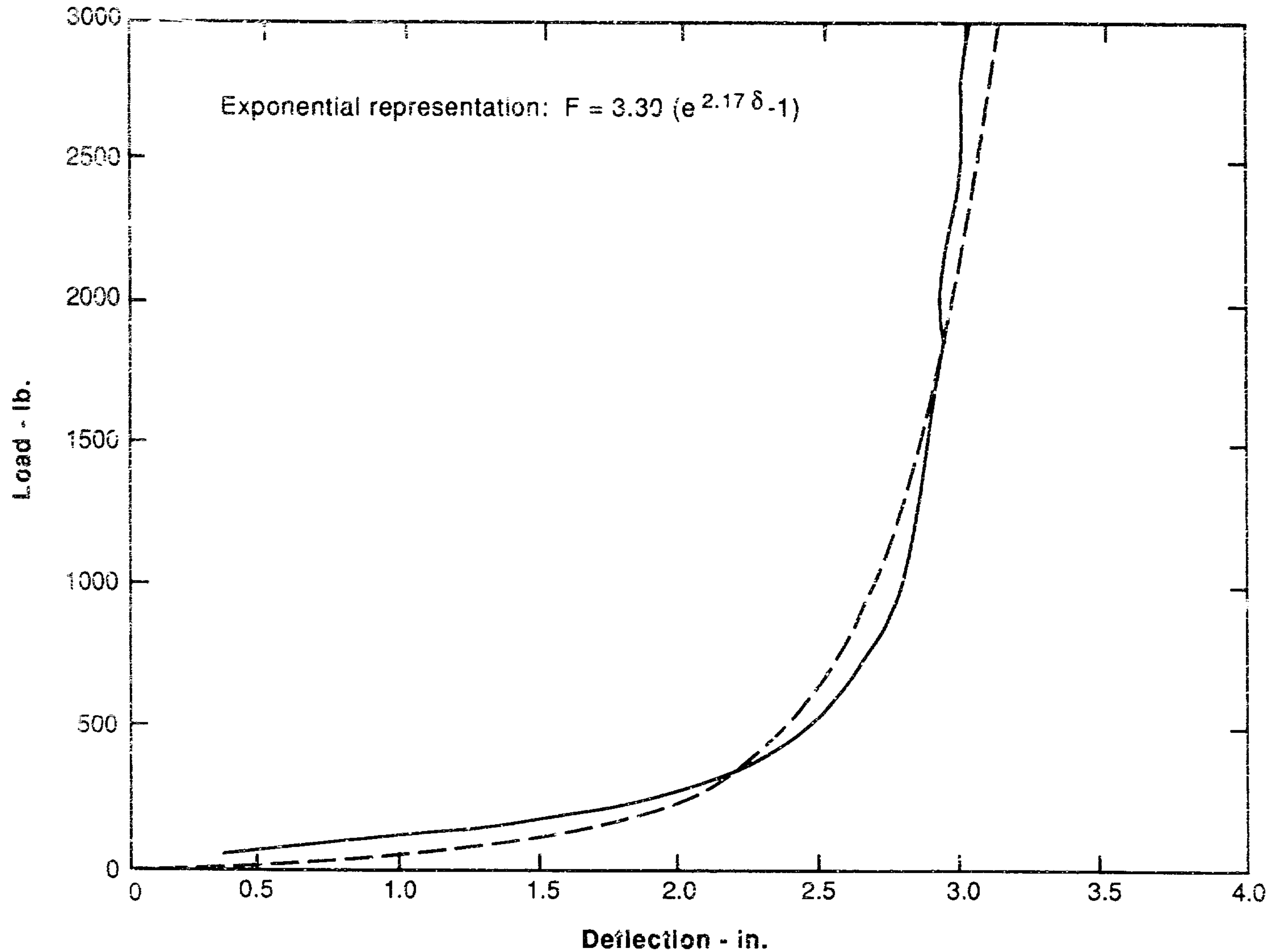


Figure B-12. Combined load-deflection curve and exponential representation for Type 3 cushion and VIP-95 dummy pelvis and buttocks.

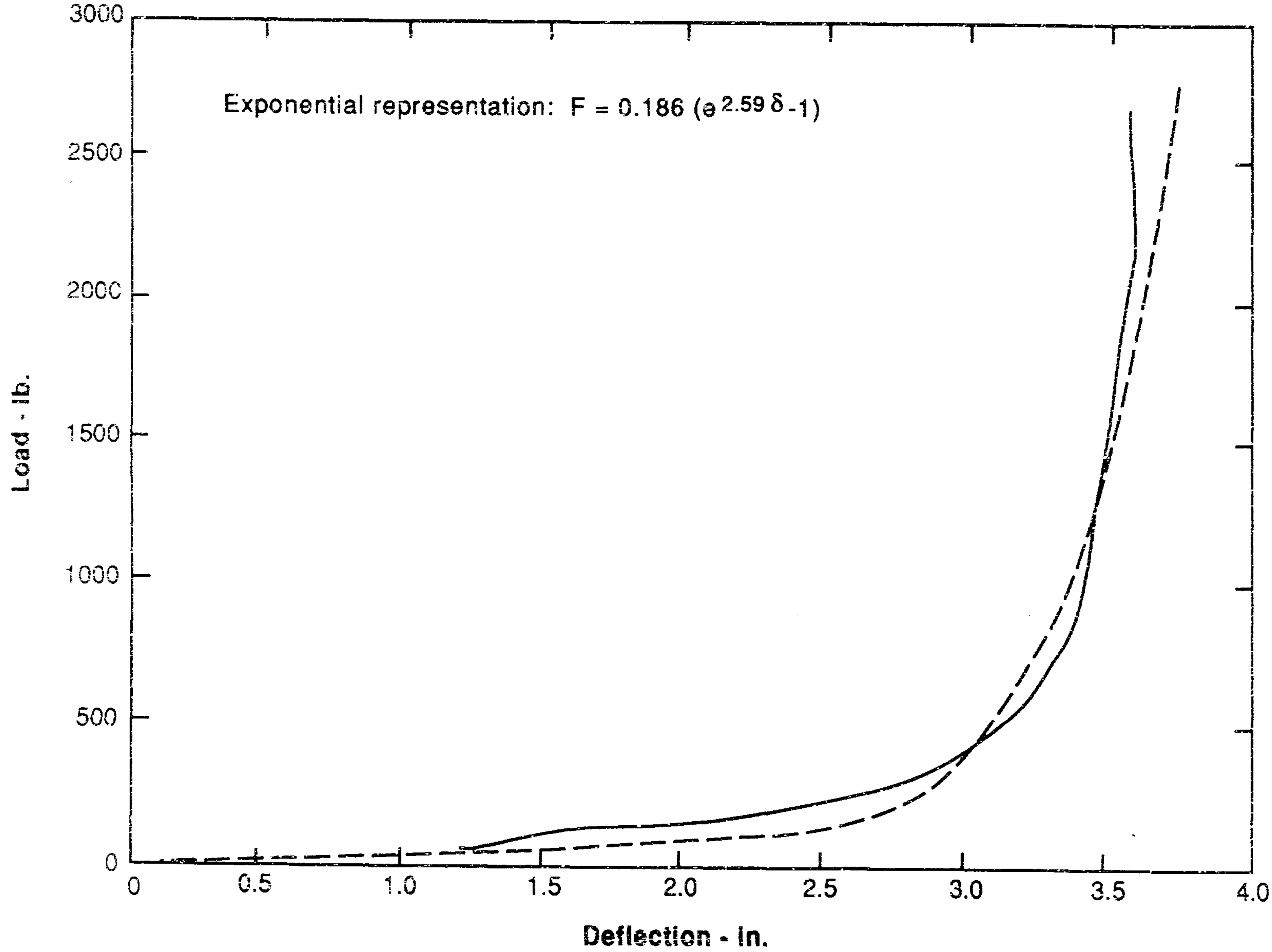


Figure B-13. Combined load-deflection curve and exponential representation for Type 4 cushion and VIP-95 dummy pelvis and buttocks.

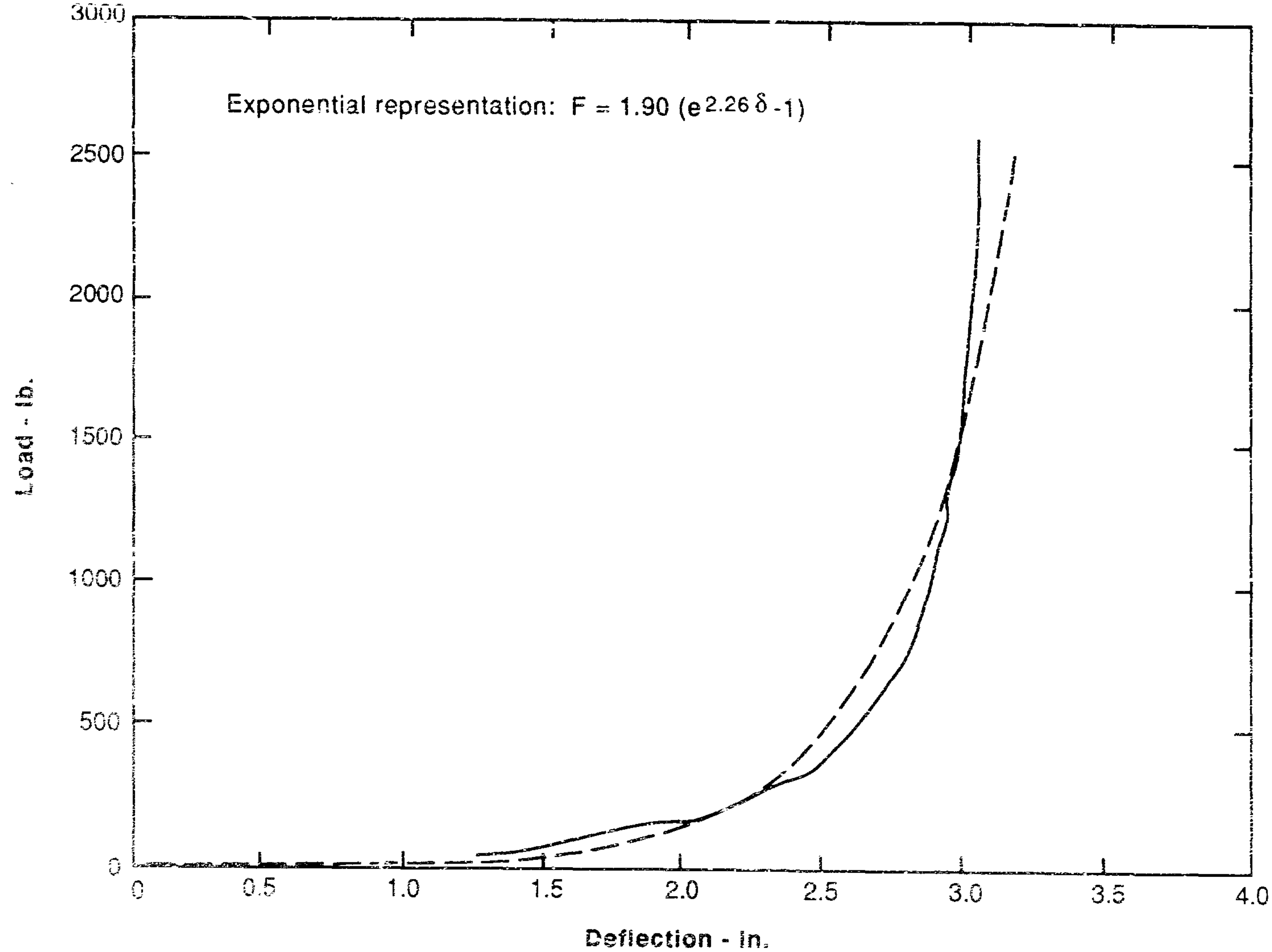


Figure B-14. Combined load-deflection curve and exponential representation for Type 5 cushion and VIP-95 dummy pelvis and buttocks.

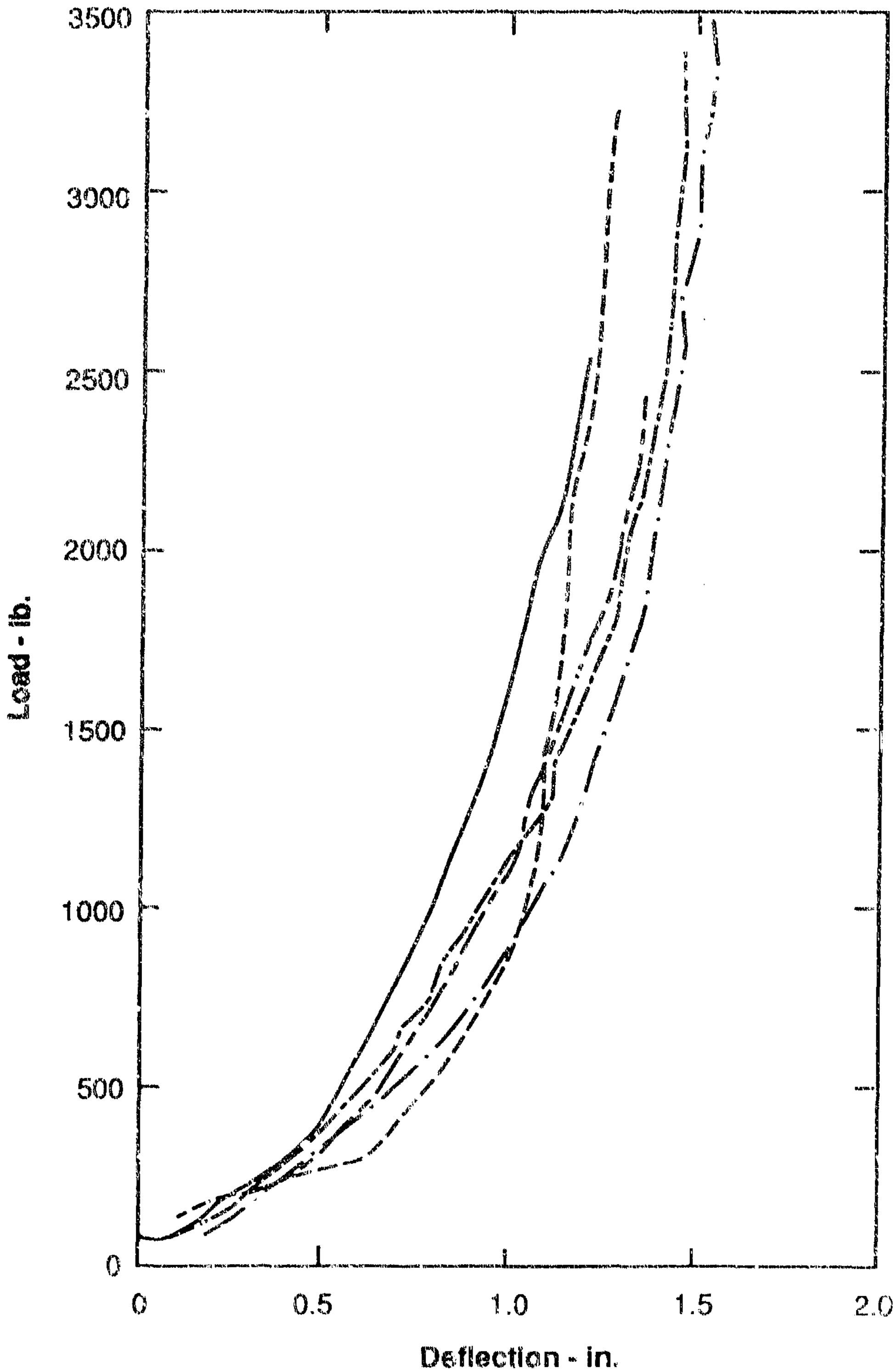


Figure B-15. Load-deflection curves for Alderson VIP-95 dummy pelvis and buttocks tested with five different cushions.

Approximate Material Properties

Modulus of elasticity, E(2) = 30 x 10^6 psi
First yield stress, E(3) = 58,700 psi
First plastic modulus, E(4) = 2.9 x 10^6 psi
Ultimate stress, E(6) = 67,000 psi
Second yield stress, E(8) = 62,500 psi
Second plastic modulus, E(9) = 75,000 psi

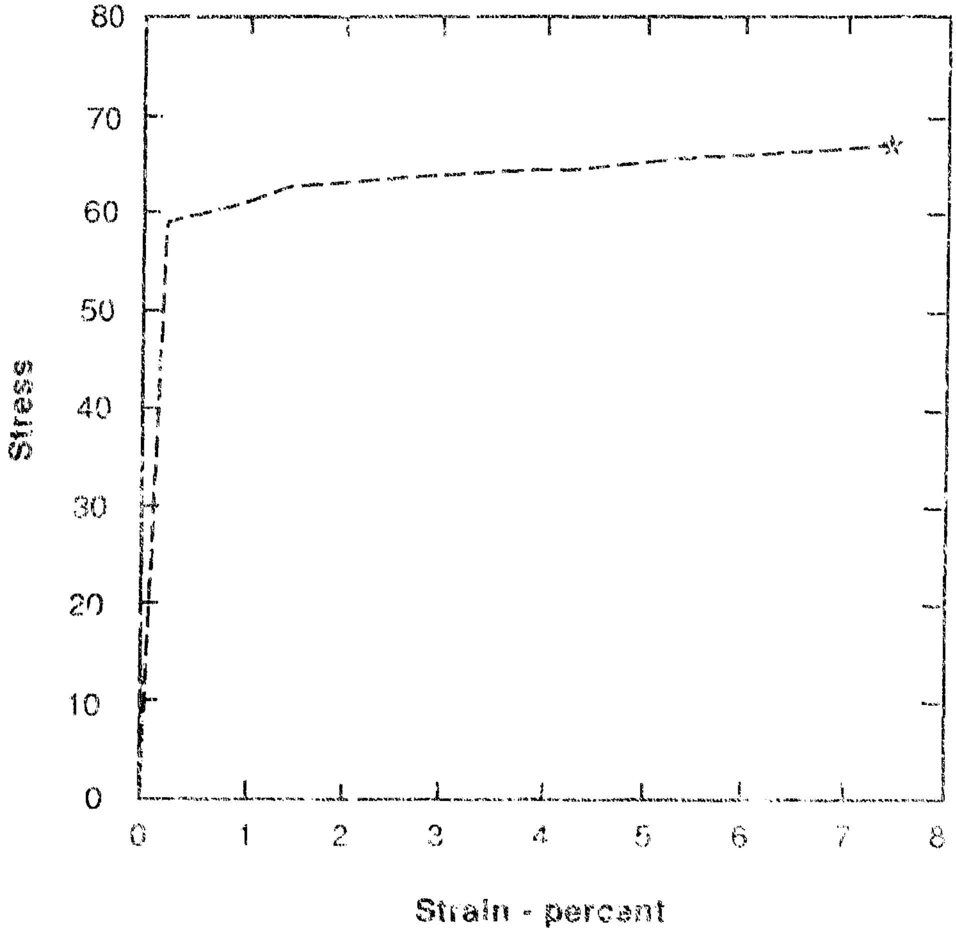
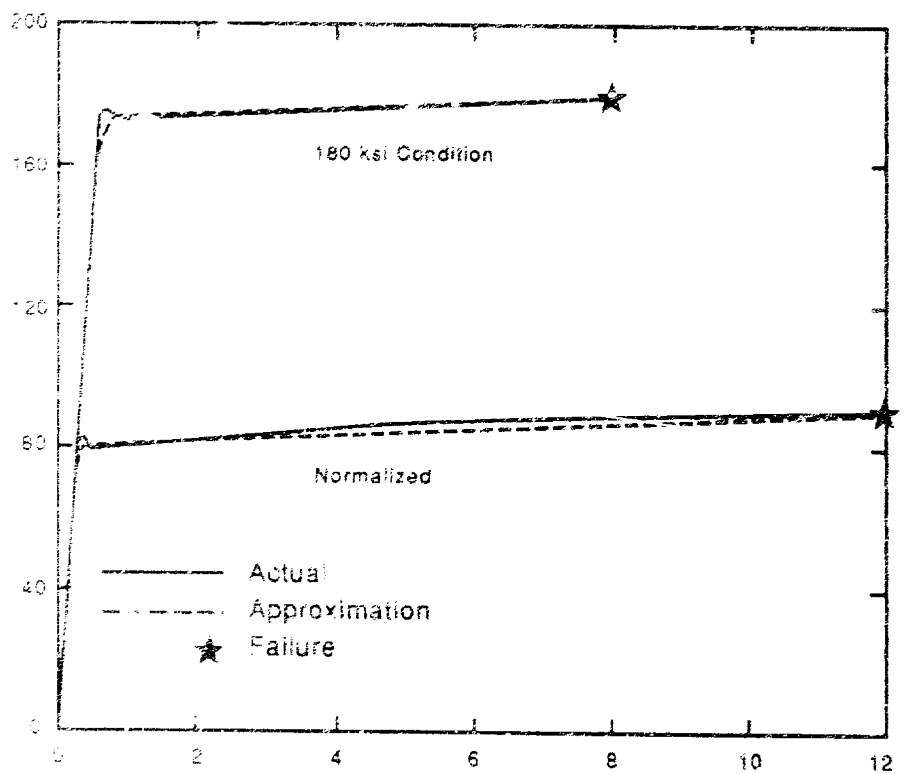


Figure B-16. Piecewise, linear approximation of stress-strain curve for 1010 cold-drawn steel.



Approximate Material Properties

Modulus of elasticity, E(2) = 29.0 x 10^{6} psi
First yield stress, E(3) = 163,000 psi
First plastic modulus, E(4) = 6.0 x 10^{6} psi
Ultimate stress, E(6) = 180,000 psi
Second yield stress, E(8) = 174,000 psi
Second plastic modulus, E(9) = 8.1 x 10^{4} psi

Approximate Material Properties For Normalized State

Modulus of elasticity, E(2) = 29.0 x 10^{6} psi
First yield stress, E(3) = 70,000 psi
First plastic modulus, E(4) = 7.0 x 10^{6} psi
Ultimate stress, E(6) = 90,000 psi
Second yield stress, E(8) = 80,000 psi
Second plastic modulus, E(9) = 1.0 x 10^{5} psi

Figure B-17. Typical tensile stress-strain curves for AISI 4130 steel heat treated to 180 ksi and normalized state, and piecewise, linear approximation to curves.

Approximate Material Properties

Modulus of elasticity, E(2) = 29.1×10^6 psi
First yield stress, E(3) = 160,000 psi
First plastic modulus, E(4) = 7.8×10^6 psi
Ultimate stress, E(6) = 180,000 psi
Second yield stress, E(8) = 170,000 psi
Second plastic modulus, E(9) = 8.85×10^5 psi

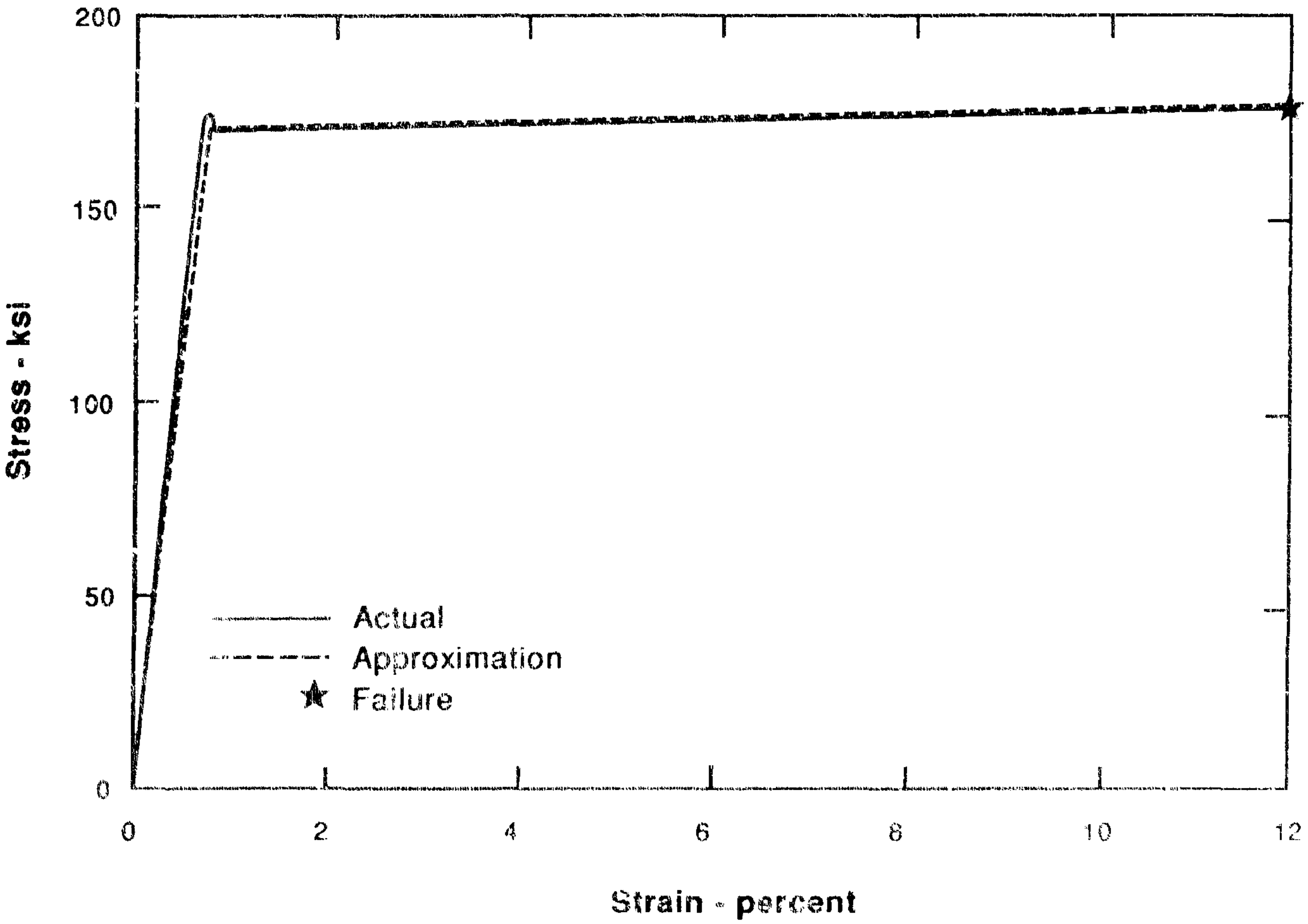


Figure B-18. Typical tensile stress-strain curve for AISI 4340 steel, heat treated to 180 ksi ultimate stress and piecewise, linear approximation to curve.

Approximate Material Properties

Modulus of elasticity, E(2) = 10.5×10^{6} psi
First yield stress, E(3) = 44,000 psi
First plastic modulus, E(4) = 4.9×10^{5} psi
Ultimate stress, E(6) = 62,000 psi
Second yield stress, E(8) = 58,000 psi
Second plastic modulus, E(9) = 6.2×10^{4} psi

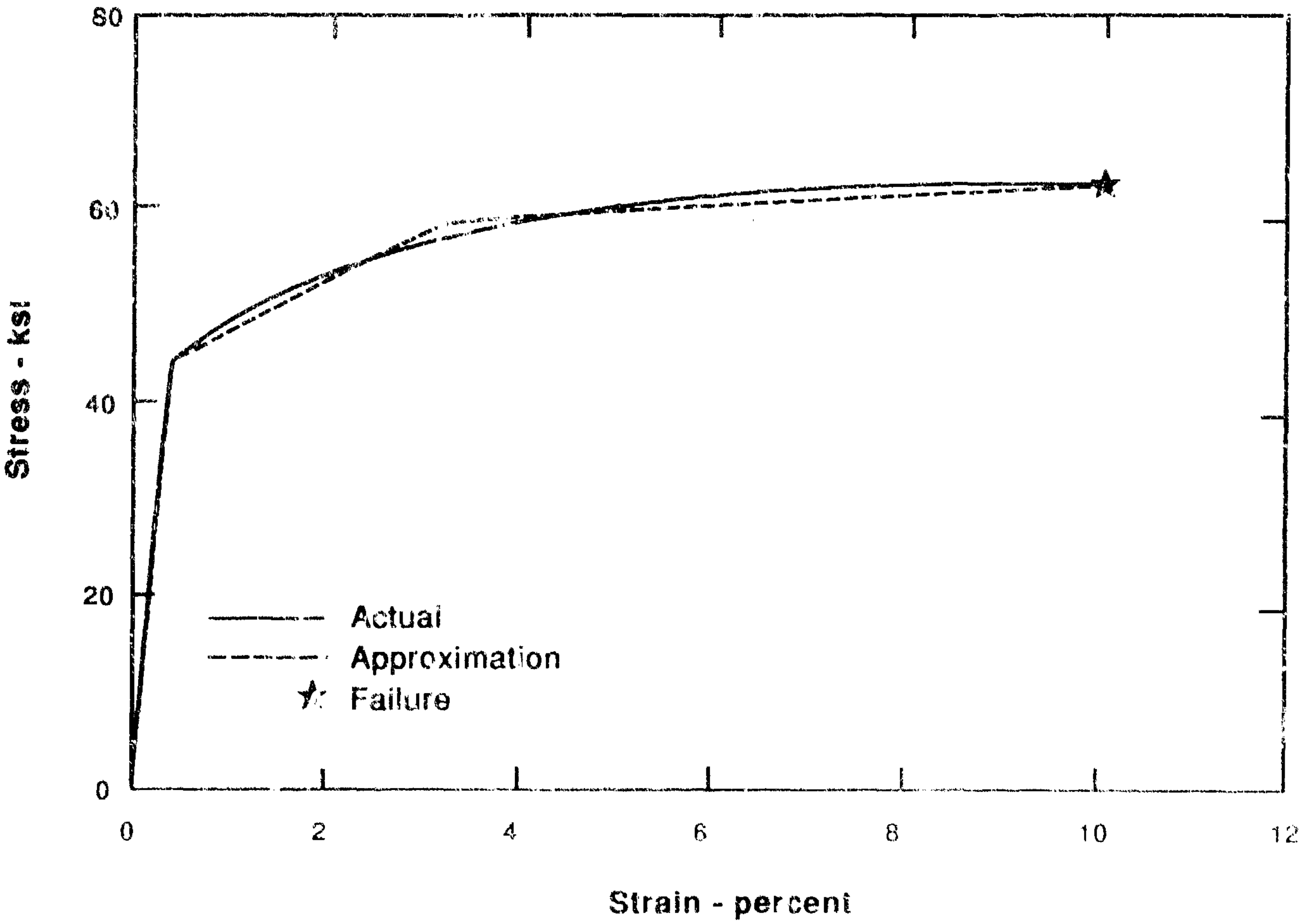


Figure B-19. Typical tensile stress-strain curve for 2024-T4 aluminum alloy and piecewise, linear approximation to curve.

Approximate Material Properties

Modulus of elasticity, E(2) = 9.9×10^{6} psi
First yield stress, E(3) = 36,200 psi
First plastic modulus, E(4) = 1.1×10^{5} psi
Ultimate stress, E(6) = 42,000 psi
Second yield stress, E(8) = 40,200 psi
Second plastic modulus, E(9) = 3.0×10^{4} psi

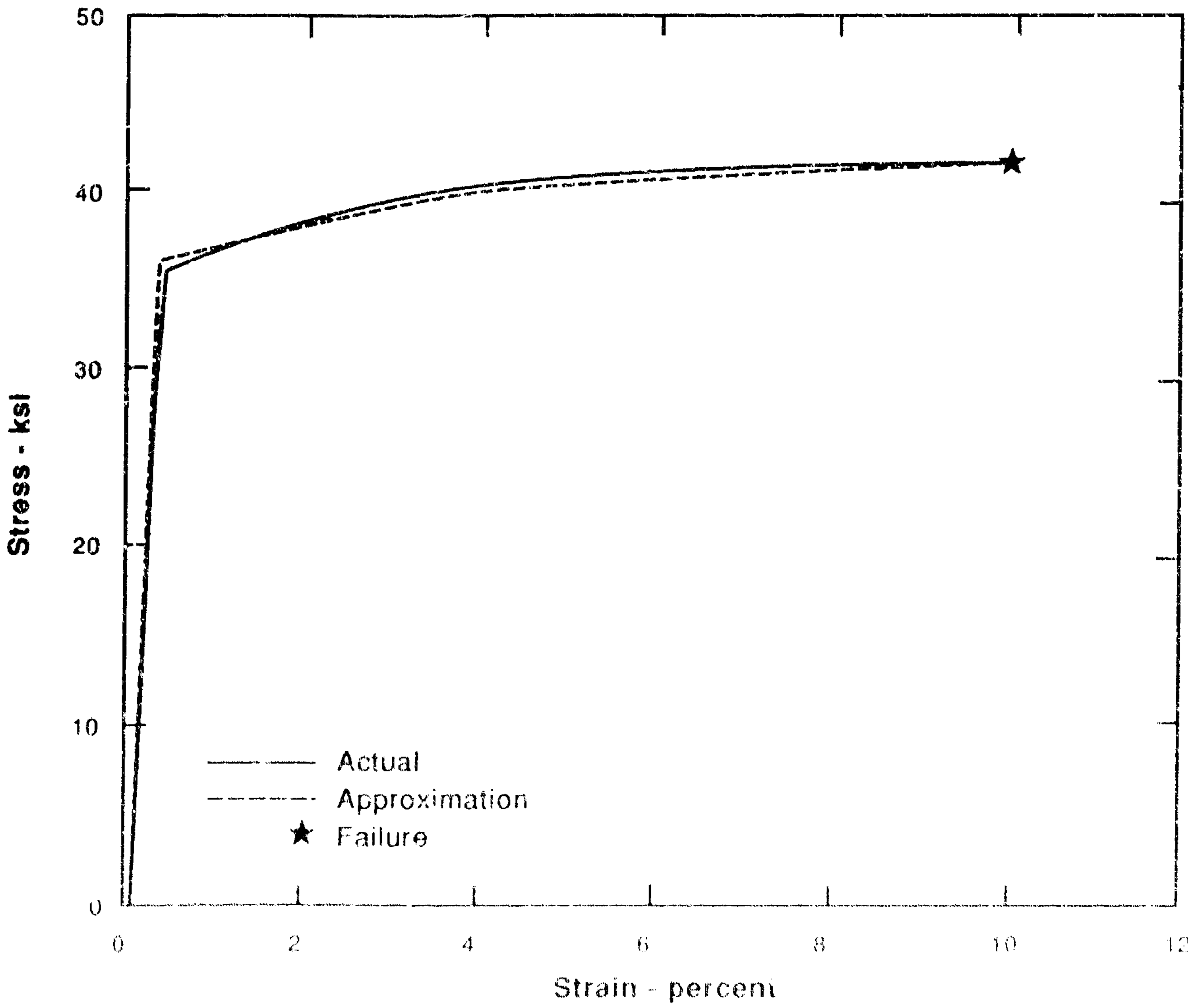


Figure B-20. Typical tensile stress-strain curve for 6061-T6 aluminum alloy and piecewise, linear approximation to curve.

APPENDIX C

PROGRAM STRUCTURE

The overall organization of Program SOM-LA/SOM-TA is illustrated in Figure C-1. The main program controls the overall solution procedure by calling two individual sets of subroutines, one for the occupant segments of the program, and the other for the seat segment of the program. Detailed descriptions of the occupant subroutines are presented in Section C.1, and the seat subroutines, in Section C.2.

At the start of execution, the main program calls subroutine INPT to read input data for the occupant model and subroutine READIN for seat input data. Subroutines CONST and INITIL calculate constants and determine initial values of generalized coordinates for the occupant, and subroutine ASSBLE performs preliminary calculations for the seat model. Then, a solution loop is entered at initial time and passed through for each time step. During each pass through the solution loop, subroutine RKAM advances the solution for the occupant equations of motion one time step and provides forces to be applied to the seat model by the occupant. After the call to RKAM, if the finite element seat model is being used, subroutine SOLVE advances the solution by the seat structural analysis to the same point in time that has been attained by RKAM. At time intervals selected by user input, subroutine ANSWER stores, in arrays, user-selected items of output data. Data for post-processing plot programs are written on external files 14 and 20 for the occupant and seat, respectively. Additional data are written on unit 26, as described in Section 3.4. These files must be saved if plots are desired.

C.1 OCCUPANT SUBROUTINE DESCRIPTIONS

The relationship among the subroutines in the occupant segment of the program is illustrated in Figure C-2. Individual subroutines are described below.

C.1.1 Subroutine AMATRX. Called by EQUATE; calculates elements of the inertia matrix [A] for the three-dimensional occupant model.

C.1.2 Subroutine AMATX2. Called by EQUAT2; calculates elements of the inertia matrix for the plane-motion occupant model.

C.1.3 Subroutine ANSWER. Called by MAIN; calculates accelerations AC(I, J) of body segments in the inertial coordinate system and transforms the accelerations to segment-fixed coordinate systems. Calculates severity indices and organizes position, velocity, and force data for output. Writes plot data on units 14 and 26. If data filtering is requested by user input, ANSWER writes occupant accelerations on unit 9 and seat accelerations on unit 10 for subsequent filtering by subroutine OUTPT. Also called by EQUATE, EQUAT2, FOBODY, LINV3F, or SOLVE in the event of abnormal termination.

C.1.4 Subroutine ARCREF. Called initially by INPT, then by POSTON; calculates current acceleration components at the aircraft floor (ACC(J), J = 1, 3) based on input acceleration pulses. Integrates acceleration to determine velocity (in aircraft coordinate system) and displacement (in inertial system). When time is greater than the input pulse duration, acceleration is set to zero, so that velocity then remains constant.

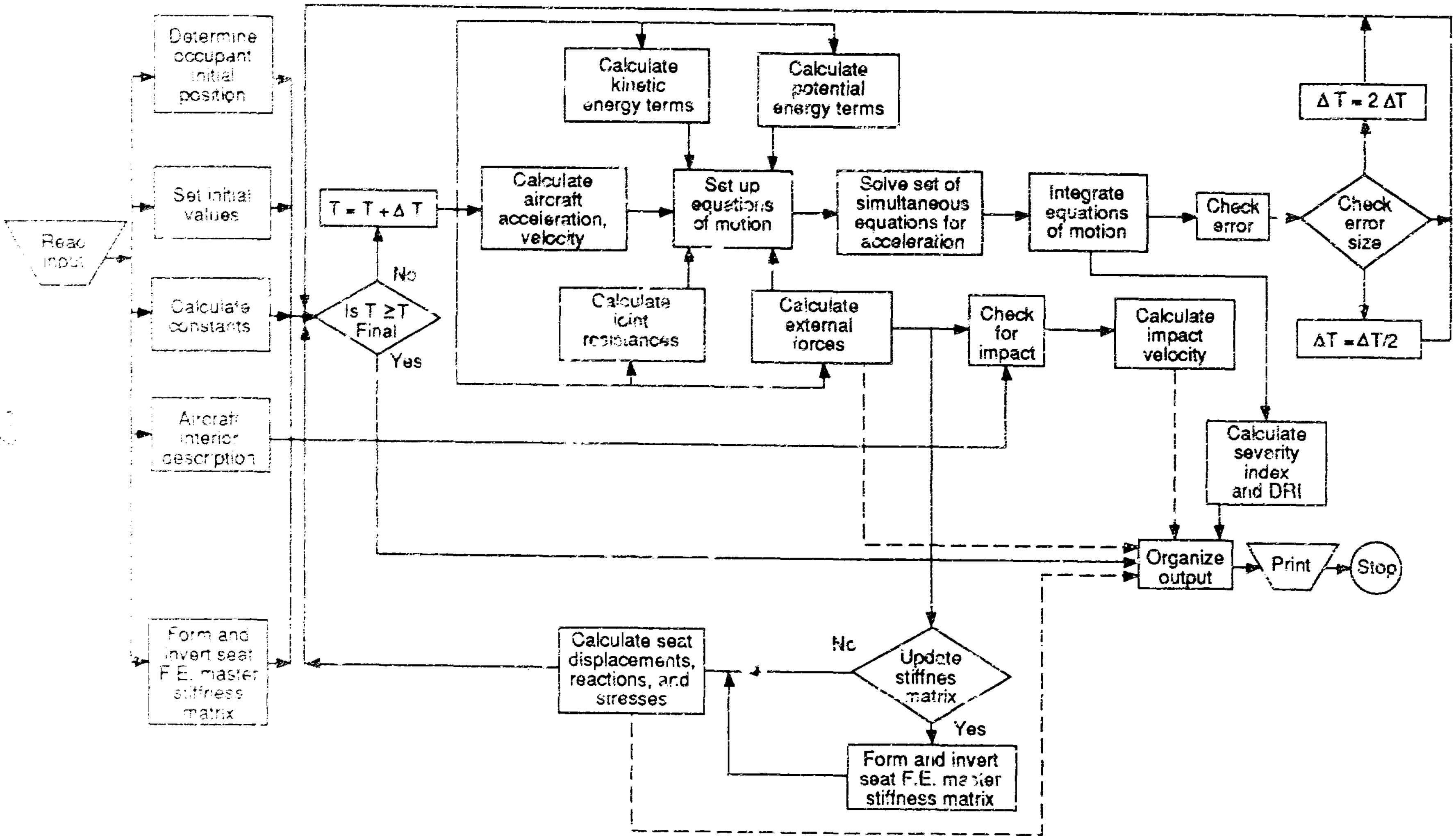


Figure C-1. Overall organization of Program SOM-TA.

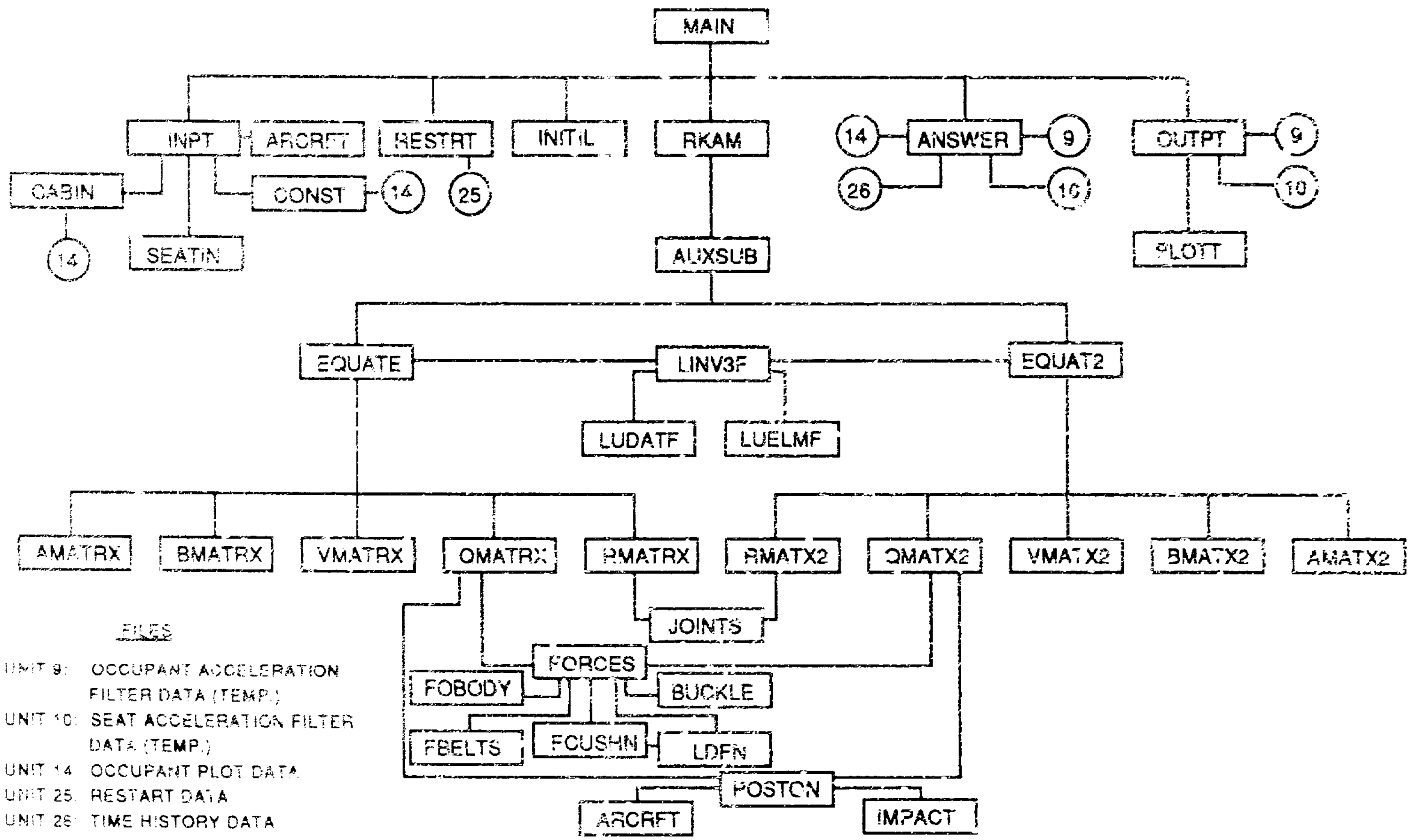


Figure C.2 SOM-LA/SOM-TA Program Structure: Occupant Segment.

C.1.5 <u>Subroutine AUXSUB</u>. Called by RKAM (also initially by MAIN); calculates derivatives and forms two 1 x 2N arrays of variables and derivatives:

V(1)	=	Q(1)	DER(1)	=	QD(1)
.	.		.		.
.	.		.		.
.	.		.		.
V(N)	=	Q(N)	DER(N)	=	QD(N)
V(N+1)	=	QD(1)	DER(N+1)	=	QDD(1)
.	.		.		.
.	.		.		.
.	.		.		.
V(2N)	=	QD(N)	DER(2N)	=	QDD(N)

where N is the number of degrees of freedom, either 12 for the plane-motion model or 29 for the three-dimensional model. The velocity and acceleration of the DRI model are assigned to DER(2N+1) and DER(2N+2), respectively. If the two-degree-of-freedom energy-absorbing seat model is used, its velocities and accelerations are assigned to DER(2N+3) through DER(2N+6).

EQUATE is called to provide values of the derivatives (the generalized velocities, QD(J), and accelerations, QDD(J)). RKAM then integrates the two systems of first-order equations.

C.1.6 <u>Subroutine BMATRX</u>. Called by EQUATE; calculates elements of velocity-dependent vector {B} for the three dimensional model.

C.1.7 <u>Subroutine BMATX2</u>. Called by EQUAT2; calculates elements of vector {B} for the plane-motion model.

C.1.8 <u>Subroutine BUCKLE</u>. Called by FORCES; determines position of the point of intersection between abdominal contact surface and thigh contact surfaces (projected on X-Z plane).

C.1.9 <u>Subroutine CABIN</u>. Called by INPT; computes coordinates for the image of the seat in front of that being modeled. These coordinates are then available for use by the passenger plot program. If seat back breakover is being modeled, CABIN is called by AUXSUB to compute derivatives for seat back motion.

C.1.10 <u>Subroutine CONST</u>. Called by INPT, once for each passenger; based on input data, calculates values of parameters that remain constant throughout program execution. These constants include functions of occupant dimensions used in the equations of motion and joint resistance parameters.

CONST also writes occupant dimensions on unit 14 for plotting.

C.1.11 <u>Subroutine EQUATE</u>. Called by AUXSUB for the three-dimensional occupant, uses the latest values of generalized coordinates and velocities to calculate terms in occupant equations of motion. Solves equations of motion for accelerations QDD(J).

Calls AMATRX, BMATRX, VMATRX, RMATRX, and QMATRX in setting up the equations of motion and calls LINV3F for their solution

C.1.12 Subroutine EQUAT2. Called by AUXSUB for the plane-motion occupant; uses latest values of generalized coordinates and velocities to calculate terms in occupant equations of motion. Solves equations of motion for accelerations QDD(J).

Calls AMATX2, BMATX2, VMATX2, RMATX2, and QMATX2 in setting up the equations of motion and calls LINV3F for their solution.

C.1.13 Subroutine FBELTS. Called by FORCES to compute restraint system forces.

C.1.14 Subroutine FCUSHN. Called by FORCES to compute seat cushion forces. The cushion forces include frictional components whose directions oppose the current velocity of the occupant with respect to the cushion.

C.1.15 Subroutine FCBODY. Called by FORCES if IRSYS = 0 for lap belt only; checks for head/leg and chest/leg contact. If contact occurs, the force is calculated based on an exponential function. The components of the force are then added to the F array already computed by FORCES.

C.1.16 Subroutine FORCES. Called by QMATRX or QMATX2; calls FBELTS, FCUSHN, and FCBODY to compute external forces; calculates forces exerted on the occupant by the floor. Sums forces and transforms them to inertial coordinate system for equations of motion.

The forces are placed in an array (F(I, J), I = 1, 11, J = 1, 3) for use in QMATRX or QMATX2.

If the two-degree-of-freedom energy-absorbing seat model is used, the translational and rotational accelerations are calculated.

C.1.17 Subroutine IMPACT. Called by FORCES; computes the point of closest proximity between each contact surface on the occupant and the seat in front. DELIMP(N,J) is the penetration of occupant surface N into surface J on the seat back in front. If DELIMP(N,J) ≥ 0 the impact velocity VELIMP(N,J) is calculated. Calculates forces due to seat back contact.

C.1.18 Subroutine INITIL. Called by MAIN, once for each passenger; calculates initial values of the generalized coordinates and velocities for the occupant and the initial deflections of the seat. INITIL first uses input values of GAM(J) to determine the angular position of the body segments 1 through 7. Based on the aircraft orientation, the occupant's weight is applied to the seat and restraint system, and the position of the lower torso segment (X_1, Y_1, Z_1) is determined. From the X and Z coordinates of segment 1 (computed here) and of the occupant's heels (from INPT) the position of the leg segments is calculated. Throughout these computations, the body is assumed to be symmetric with respect to the aircraft (X-Z) plane.

If the seat is initially warped so that the seat back angle is changed, the values of GAM(1), GAM(2), and GAM(3) are adjusted accordingly.

In the event that the input initial conditions impose unreasonable requirements on occupant geometry, a diagnostic message is provided and execution is stopped.

C.1.19 Subroutine INPT. Called by MAIN; reads occupant input data. Detailed descriptions of input are presented in Chapter 2 and Appendix A.

C.1.20 Subroutine JOINTS. Called by RMATRX or RMATX2; fits a cubic curve into the transition region of the joint stopping moments.

C.1.21 Subroutine LDFN. Called by FBELTS and by FORCES; uses linear interpolation in a table of force (Y) versus deflection (X) values. A description of the parameters in the calling sequence follows:

X	A table of the independent variable, x_i, such that $x_{i+1} \geq x_i$ (if ICHK = 0).
Y	The table of the dependent variable, $y_i = y(x_i)$ (if ICHK = 0).
N	The number of entries in each of the above tables; i = 1,...N.
XA	The independent variable, x, for which interpolation is requested.
XLAST YLAST	Previous values of XA and YA.
ICHK	Index which is 0 or 1 depending on call during loading or unloading.
XCURV YCURV	Point on loading curve from which unloading started.
C	Unloading slope, used only if IUNLD = 2.
YA	The dependent variable, y = y(x), being determined.
IUNLD	Index which is 2 if unloading slope, C, is to be used, 1 if unloading proceeds along basic loading function.

C.1.22 Subroutine LINV3F. Called by EQUATE and EQUAT2; performs linear equation solution:

A	Input/output matrix of dimensions N x N. See parameter IJOB.
B	Input/output vector of length N. On input, B contains the right-hand side of the equation AX = B. On output, the solution X replaces B.
IJOB	Input option parameter. IJOB = 2 implies solve the equation AX=B. A is replaced by the LU decomposition of a rowwise permutation of A, where U is upper triangular and L is lower triangular with unit diagonal. The unit diagonal of L is not stored.
N	Order of A. (input).
IA	Row dimension of A as specified in the calling program. IA must be greater than or equal to N. (input).
D1,D2	If D1 is non-negative on input, then D1 and D2 will be components of the determinant on output such that determinant (A) = D1*2**D2.
WKAREA	Work area of length at least N when IJOB = 2.
IER	Error parameter. Terminal error = 128+N, whereN = 2 indicates that matrix A is algorithmically singular.

C.1.23 Subroutine LUDATF. Called by LINV3F; performs L-U decomposition by the Crout algorithm with optional accuracy test.

A	Input matrix of dimension N x N containing the matrix to be decomposed.
LU	Real output matrix of dimension N x N containing the L-U decomposition of a rowwise permutation of the input matrix.
N	Input scalar containing the order of the matrix A.
IA	Input scalar containing the row dimension of matrices A and LU in the calling program.
IDGT	Input option. If IDGT is greater than zero, the non-zero elements of A are assumed to be correct to IDGT decimal places. LUDATF performs an accuracy test to determine if the computed decomposition is the exact decomposition of a matrix which differs from the given one by less than its uncertainty. If IDGT is equal to zero, the accuracy test is bypassed.
D1	Output scalar containing one of the two components of the determinant. See description of parameter D2, below.
D2	Output scalar containing one of the two components of the determinant. The determinant may be evaluated as (D1) (2**D2).
IPVT	Output vector of length N containing the permutation indices.
EQUIL	Output vector of length N containing reciprocals of the absolute values of the largest (in absolute value) element in each row.
WA	Accuracy test parameter, output only if IDGT is greater than zero.
IER	Error parameter. Terminal error = 128+N. N = 1 indicates that matrix A is algorithmically singular. Warning error = 32+N. N = 2 indicates that the accuracy test failed. The computed solution may be in error by more than can be accounted for by the uncertainty of the data. This warning can be produced only if IDGT is greater than 0 on input.

C.1.24 Subroutine LUELMF. Called by LINV3F; performs the elimination part of the solution of AX = B, in full-storage mode.

A	The result, LU, computed in the subroutine LUDATF, where L is a lower triangular matrix with ones on the main diagonal. U is upper triangular. L and U are stored as a single matrix A, and the unit diagonal of L is not stored.
B	B is a vector of length N on the right-hand side of the equation AX = B.

IPVT	The permutation matrix returned from the subroutine LUDATF, stored as an N-length vector.
N	Order of A and number of rows in B.
IA	Number of rows in the dimension statement for A in the calling program.
X	The result X.

C.1.25 Subroutine OUTPT. Called by MAIN; writes output data, along with headings, on the output file. The parameter IOUT(J) from input determines whether the output file receives data of Type J. For example, output category No. 1 is occupant segment position information. If IOUT(1) = 1, these data go to output; if IOUT(1) = 0, they do not. Also performs filtering of acceleration data if requested in input. Called by EQUATE, EQUAT2, FOBODY, or SOLVE in the event of abnormal termination.

C.1.26 Subroutine PLOTT. Called by OUTPT; provides printer plots for up to three dependent, continuous, single-valued functions (Y1, Y2, Y3) against an even-incremental independent variable (X).

M	The number of dependent variables (1, 2, or 3).
NP	The number of points to be plotted for each dependent variable.
X	The independent variable.
Y1 Y2 Y3	The dependent variables.

C.1.27 Subroutine POSTON Called by QMATRX or QMATX2; uses equations of the form

$$\begin{Bmatrix} X \\ Y \\ Z \end{Bmatrix} = [T^n] \begin{Bmatrix} x_n \\ y_n \\ z_n \end{Bmatrix}$$

to compute absolute positions of 29 points on body (XC, YC, ZC). Computes positions of the same 29 points in aircraft coordinate system (XCA, YCA, ZCA). Calculates velocities (XCDA, YCDA, ZCDA) for output and for use in velocity-dependent form computation.

C.1.28 Subroutine QMATRX. Called by EQUATE for the three-dimensional model; calculates elements of generalized force vector $\{Q_f\}$. Calls FORCES for computation of external forces acting on occupant.

C.1.29 Subroutine QMATX2. Called by EQUAT2 for the plane-motion model; calculates elements of generalized force vector $\{Q_f\}$. Calls FORCES for computation of external forces acting on occupant.

C.1.30 Subroutine RESTRT. Called by MAIN at input-specified intervals to generate data files on unit 25 for restarting solution at time later than zero. Called by INITIL when solution is restarted to read data previously stored on unit 25

C.1.31 Subroutine RKAM. Called by MAIN; solves a set of N simultaneous, first-order, ordinary differential equations. Because of the importance of the integration scheme to the success of any dynamic analysis program, a detailed discussion of the method is provided along with the description of the FORTRAN subroutine.

Method - The user is allowed an option of using either the Runge-Kutta classical fourth-order method or the Adams-Moulton predictor-corrector method using the Runge-Kutta method for starting the process.

The system of equations to be solved is:

$$y_i' = f_i(x, y_1, y_2 \ldots, y_N)$$

$$i = 1, 2, \ldots, N \qquad \text{(C.1)}$$

$$y_i(x_o) = y_{io}$$

Let y_{in} be the value of y_i at $x = x_n$ and f_{in} the derivative of y_i at $x = x_n$, and let h be the increment (step size) of the independent variable x. The classical Runge-Kutta fourth-order method uses the formulas

$$k_{i1} = hf_i(x_n, y_{in}),$$

$$k_{i2} = hf_i(x_n + {}^1/_2\, h, y_{in} + {}^1/_2\, k_{i1}),$$

$$k_{i3} = hf_i(x_n + {}^1/_2\, h, y_{in} + {}^1/_2\, k_{i2}), \qquad \text{(C.2)}$$

$$k_{i4} = hf_i(x_n + H, y_{in} + k_{i3}),$$

$$y_{i,n+1} = y_n + {}^1/_6\, (k_{i1} + 2k_{i2} + 2k_{i3} + k_{i4})$$

The normal option is to continue the integration with Adams-Moulton predictor-corrector formulas once enough back values have been generated by the Runge-Kutta method.

The Adams-Moulton predictor-corrector formulas for the system (C.1) are

$$y^{(p)}_{i,\,n+1} = y_{i,n} + \frac{h}{24}\left(55f_{i,n} - 59f_{i,n-1} + 37f_{i,n-2} - 9f_{i,n-3}\right) \qquad \text{(C.3)}$$

$$y^{(c)}_{i,\,n+1} = y_{i,n} + \frac{h}{24}\left(9f^{(p)}_{i,n+1} + 19f_{i,n} - 5f_{i,n-1} + f_{i,n-2}\right) \qquad \text{(C.4)}$$

The corrector formula (C.4) is applied only once per step so that only two derivative evaluations are needed for each Adams-Moulton integration step. The starting values needed in (C.3) are initially obtained using the Runge-Kutta method.

The Adams-Moulton method may be used with either a fixed step size or a variable step size. The step size to be used in the variable mode is determined from the difference between the predicted and corrected values. The integration step size is thus controlled dynamically between prescribed error bounds so that execution speed and accuracy can be optimized.

Restrictions - An auxiliary routine must be provided for evaluation of the first-order derivatives. (See AUXSUB under Calling Sequence.)

Initial conditions for both variables and derivatives must be stored in their respective locations prior to entering RKAM.

Calling Sequence

XDP	=	x, the independent variable
HDP	=	h, the integration step size
VAR	=	N-dimensional vector of dependent variables ($y_1, y_2, \ldots, y_n$)
DER	=	N-dimensional vector of derivatives ($y_1', y_2', \ldots, y_n'$)
AUXSUB	=	Name of the auxiliary routine that computes derivatives and stores them in DER(1) to DER(N). The main program, which calls RKAM, must contain an EXTERNAL statement. No items are allowed in the calling sequence.
N	=	Number of equations
OPT	=	Option indicator, zero for AM, non-zero for RK only
EU	=	N-dimensional vector of upper bounds from main program
EL	=	N-dimensional vector of lower bounds from main program
HMAX	=	Absolute value of maximum allowable step size
HMIN	=	Absolute value of minimum allowable step size (HMIN > 0)
ICNT	=	Internal counter, set to zero initially in MAIN
TEMPS	=	A two-dimensional, (9,N) storage region. TEMP (1,I), I = 1, N must be set to zero initially or when restarting
NH	=	Index of the equation that caused halving when step size has been reduced

VAR, DER, and all other locations referred to in both the main program and the auxiliary subroutine must be assigned in COMMON statements. (If the step size were to be changed outside of RKAM, the restart flag, ICNT, should be set to zero.) This restriction does not apply in the "RK only" mode. HMAX, HMIN, EU, and EL are also irrelevant in this mode.

Functional Description - The subroutine employs the fourth-order Adams-Moulton predictor-corrector method using the classical fourth-order Runge-Kutta method to obtain starting values.

AM has the following advantages with respect to RK:

1. Only half as many derivative evaluations per integration step are required to attain the same order of accuracy.

2. The local truncation error may be estimated at the conclusion of each integration step thereby providing a means for step size control.

For each variable, the local truncation error is approximately one-fourteenth the difference between the predicted and corrected values, that is

$$e_i = \frac{1}{14} \left| y_i^{(c)} - y_i^{(p)} \right| \tag{C.5}$$

In RKAM, the differences $D_i \equiv \left| y_i^{(c)} - y_i^{(p)} \right|$ are formed and compared with positive numbers EU_i and EL_i. If $D_i \geq EU_i$ for <u>any</u> i, the step size is halved provided $|h/2| \geq$ HMIN. If $D_i < EL_i$ for <u>all</u> i and for three successive steps, the step size is doubled provided $|2h| \leq$ HMAX. (Note that h may be held fixed either by setting HMIN = HMAX or by making EU_i and EL_i prohibitively large and small, respectively.) If halving is called for during the first AM step following the three initial RK steps, the step size is halved, the independent variable is set back to its initial value, and the three RK steps are repeated. This will continue until the first AM step is successfully taken. From this point on, halving is effected by interpolation of past data whereas doubling is accomplished by alternate selection of past data.

In selecting EU and EL, one should note the following:

1. The test is an absolute test. To control relative error EU_i and EL_i should be computed as functions of y_i prior to each integration step.

2. Although the local truncation error in y_i is not allowed to exceed EU_i, this does not imply that the cumulative error will not exceed EU_i. Therefore, EU_i and EL_i should depend upon the maximum allowable cumulative error and the number of integration steps.

3. Since doubling h will multiply the truncation error by a factor of 2^5, EL_i should be chosen less than $EU_i/32$ if the advantages of doubling are not to be short-lived.

C.1.32 <u>Subroutine RMATRX</u>. Called by EQUATE for the three-dimensional model; calculates elements of joint resistance vector {R}. Input parameter IMAN determines whether human (IMAN = 0) or dummy (IMAN = 1) model is used.

C.1.33 <u>Subroutine RMATX2</u>. Called by EQUAT2 for the plane motion model; calculates elements of joint resistance vector {R}

C.1.34 <u>Subroutine SEATIN</u>. Called by INPT; reads input data required for rigid seat model and energy-absorbing option.

C.1.35 Subroutine VMATRX. Called by EQUATE for the three-dimensional model; calculates elements of force vector $\{F_p\}$ derived from system potential energy.

C.1.36 Subroutine VMATX2. Called by EQUAT2 for the plane-motion model; calculates elements of force vector $\{F_p\}$ derived from system potential energy.

C.2 SEAT SUBROUTINE DESCRIPTIONS

The relationships among the subroutines in the seat segment of the program are illustrated in Figure C-3. Individual subroutines are described below.

C.2.1 Subroutine ASSBLE. Called by MAIN; initializes the element data storage. The mass matrix and the initial transformations $\underline{B}_o$ for the nodal coordinate systems are assembled, and the initial values of the pointing vectors $\bar{n}$, $\bar{\eta}$, and $\bar{\xi}$ and the normal components of the rigid links $\bar{\Delta}$ are generated.

C.2.2 Subroutine ASSMBL. Called by PLSTF and BMSTF; assembles the master stiffness matrix in a banded symmetric form. This subroutine calls subroutine KADD, which adds a particular element of the square element stiffness matrix to the banded master stiffness matrix.

C.2.3 Subroutine BASME. Called by ASSBLE; forms the initial element coordinate system $\underline{E}$ for beam and spring elements.

C.2.4 Subroutine BFRCIN. Called by FRCIN; calculates the beam and spring element deformations and nodal forces in the element coordinate system. Performs the operations associated with the master-slave relations and transforms the forces to the nodal coordinate system.

C.2.5 Subroutine BGEOM. Called by READIN; reads the data describing the cross-section properties of beams and springs. Generates certain additional data, such as segment lengths and torsional constants.

C.2.6 Subroutine BMEND. Called by BMSTF; calculates the reduced stiffness matrix due to axial force, shear, and moment discontinuities.

C.2.7 Subroutine BMSTF. Called by SOLVE; calculates beam or spring element stiffness matrix. The principal subroutines called include BMSTF1 for elastic material, BMSTF2 for inelastic material, BMEND for the modification of the stiffness due to special end conditions, and ASSMBL for assembly of element stiffness.

C.2.8 Subroutine BMSTF1. Called by BMSTF; calculates the elastic stiffness matrix for a beam or spring element.

C.2.9 Subroutine BMSTF2. Called by BMSTF; calculates the tangential stiffness matrix for a beam or spring element.

C.2.10 Subroutine BOUND. Called by SOLVE; applies the specified boundary conditions to the assembled master stiffness matrix.

C.2.11 Subroutine CROSS. Utility subroutine; calculates the cross product of two matrices.

C.2.12 Subroutine CRVTBL. Called by EPTSTF; contains plate bending curvature tables.

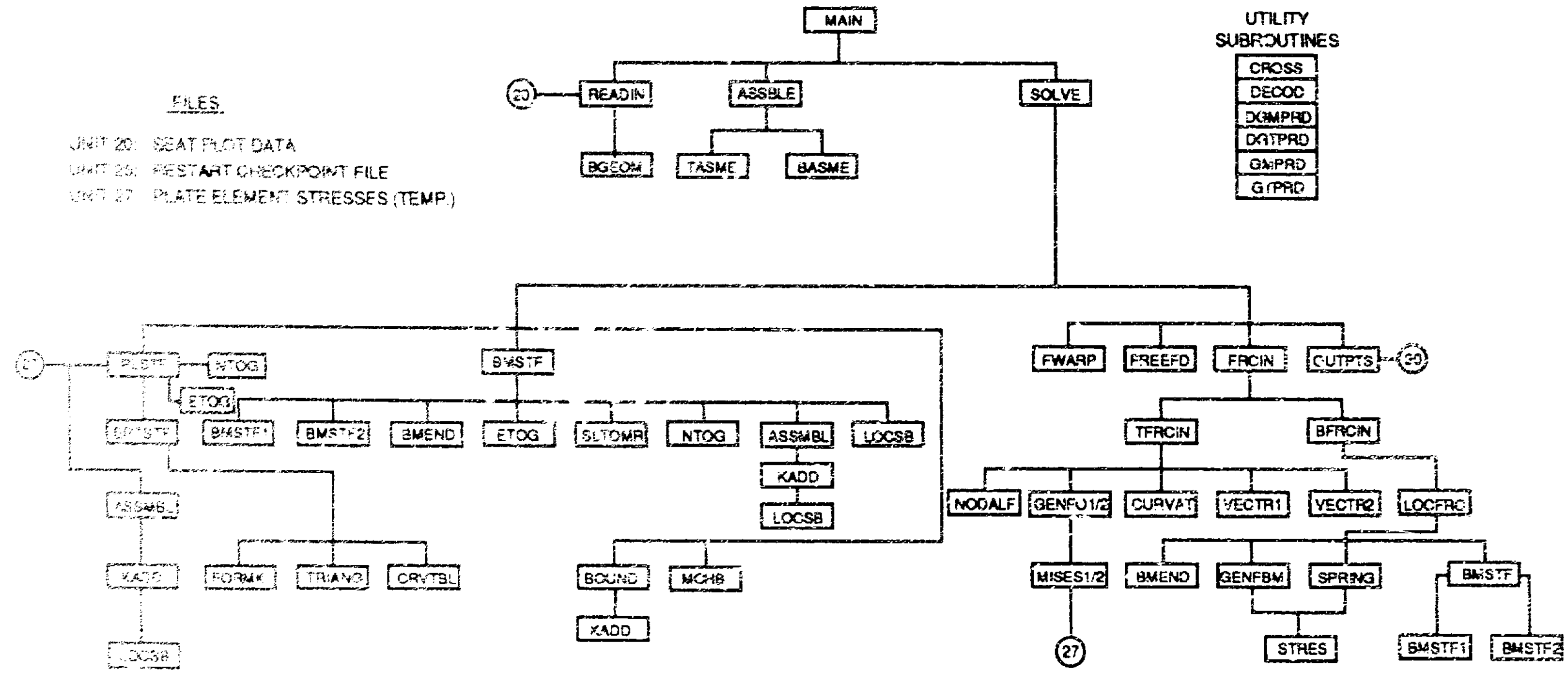


Figure C-3. SOM-LA/SOM-TA Program Structure: Seat Segment.

C.2.13 Subroutine CURVAT. Called by TFRCIN; provides algebraic expressions for curvature components at the midpoints of the three sides of the plate elements as functions of the nodal rotations.

C.2.14 Subroutine DECOD. Utility subroutine, decodes a packed word.

C.2.15 Subroutine DGMPRD. Double precision version of GMPRD.

C.2.16 Subroutine DGTPRD. Double precision version of GTPRD.

C.2.17 Subroutine EPTSTF. Called by PLSTF; calculates plate element stiffness matrix. This subroutine calls TRIANG for the in-plane strain-displacement relationship, CRVTBL for curvature, and FORMK for calculation of appropriate elements in the stiffness matrix.

C.2.18 Subroutine ETOG. Called by BMSTF and PLSTF; transforms appropriate variables from the element coordinate system to the global coordinate system.

C.2.19 Subroutine FORMK. Called by EPTSTF; calculates the products of three different matrices.

C.2.20 Subroutine FRCIN. Called by SOLVE; calculates internal nodal forces. The program updates the nodal coordinate transformations B, and calls subroutines TFRCIN for plate forces and BFRCIN for beam forces.

C.2.21 Subroutine FREEFD. Called by SOLVE; calculates the external forces including restraint system forces and forces exerted by the occupants on the seat pan and seat back.

C.2.22 Subroutine FWARP. Called by SOLVE; modifies forces to account for specified floor warp displacements and rotations.

C.2.23 Subroutine GENFBM. Called by LOCFRC; numerically integrates stresses over the cross section of the beam to obtain internal forces and moments.

C.2.24 Subroutine GENF01/GENF02. Called by TFRCIN; computes moments and forces at a cross section of an elastic-plastic plate (with/without) integrating through the thickness.

C.2.25 Subroutine GMPRD. Utility subroutine; performs general matrix multiplication.

C.2.26 Subroutine GTPRD. Utility subroutine; calculates the product of the transpose of a matrix with another matrix.

C.2.27 Subroutine KADD. Called by ASSMBL; adds a particular element of the square matrix to the banded matrix.

C.2.28 Subroutine LOCFRC. Called by BFRCIN; calculates midplane strains, curvatures, nodal forces, and moments in the beam element coordinate system. Elongation and nodal forces are also calculated for the spring in the element coordinate system.

C.2.29 Subroutine LOCSB. Called by BMSTF, BOUND, and KADD, computes the location of a particular element of a square matrix when assembled into the banded symmetric form.

C.2.30 <u>Subroutine MCHB</u>. Called by SOLVE; solves the linear system of equations $\underline{K}\,x = F$ for x (displacements). The master stiffness matrix $\underline{K}$ is assumed to be symmetric positive definite and stored in the compressed form, that is, main diagonal and upper codiagonals rowwise in successive storage locations. F is the applied force vector. This is a two-step equation solver that uses Cholesky's method. In the first step the master stiffness matrix K is factored into an upper diagonal matrix U and a lower diagonal matrix L.

$$\underline{K} = \underline{L}\,\underline{U} \tag{C.6}$$

and let $$\underline{U}\bar{x} = \bar{v} \tag{C.7}$$

so that the linear system of equations $\underline{K}\bar{x} = \bar{F}$ is equivalent to

$$\underline{L}\bar{v} = \bar{F} \tag{C.8}$$

In the second step, equation (C.8) is solved by forward reduction for v and finally equation (C.7) is solved for x by back substituting for v.

C.2.31 <u>Subroutines MISES1/MISES2</u>. Called by TFRCIN; computes biaxial elastic-plastic stress-strain relations using Von Mises yield criterion.

C.2.32 <u>Subroutine NODALF</u>. Called by TFRCIN; calculates nodal forces and moments for the plate element.

C.2.33 <u>Subroutine NTOG</u>. Called PLSTF; transforms appropriate variables from the global coordinate system to the nodal coordinate system.

C.2.34 <u>Subroutine OUTPTS</u>. Called by SOLVE; organizes and tabulates output for those quantities selected for output. Deformed seat model plot data are written onto file 20 at user-selected times.

C.2.35 <u>Subroutine PLSTF</u>. Called by SOLVE; calls EPTSTF to form the plate element stiffness matrix and then uses ASSMBL to assemble the element stiffness.

C.2.36 <u>Subroutine READIN</u>. Called by MAIN; reads all input data and, if required, initializes the data files. Undeformed seat model data and model parameters are written onto file 20 if requested.

C.2.37 <u>Subroutine SOLVE</u>. Called by MAIN; performs the main solution procedure. The principal subroutines called are BMSTF for beam or spring stiffness, PLSTF for plate stiffness, FREEFD for applied forces, MCHB for the solution of displacements, and OUTPTS for printed output and plot of selected parameters.

C.2.38 <u>Subroutine SPRING</u>. Called from LOCREC; calculates the element forces for a spring element.

C.2.39 <u>Subroutine STRES</u>. Called from GENFBM and SPRING; provides an algorithm for uniaxial stress strain relationship.

C.2.40 <u>Subroutine TASME</u>. Called from ASSBLE; calculates the contributions to the lumped mass matrix for plate elements. Forms the initial element coordinate system E for the plate elements.

C.2.41 Subroutine TFRCIN. Called from FRCIN; calculates plate element deformations and forces in the element coordinate system. The forces are then transformed to the nodal coordinate system.

C.2.42 Subroutine TRIANG. Called from EFTSFT; contains algebraic expressions of the strain-displacement relationship for a plate element.

C.2.43 Subroutine VECTR1. Called from TFRCIN; calculates the deformed lengths of plate element sides.

C.2.44 Subroutine VECTR2. Called by TFRCIN; determines the components of a vector normal to a reference surface.

APPENDIX D

LISTING OF OUTPUT FROM SAMPLE CASE NO. 1

ECHO OF INPUT DATA IN CARD IMAGE FORMAT

```
                  1         2         3         4         5         6         7         8
LINE NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890
    1               THREE-PASSENGER TRANSPORT AIRCRAFT SEAT                        00001000
    2                      SAMPLE CASE NO. 1                                       00002000
    3         2    1    1    0    0    1    0    4    1    3    3    1    1    1   00003000
    4         1    1    2    0    1    1    2    1    1    1    8    5    2        00004000
    5                0.      .180     .0005     .0005       0.1     0.001     .0005 00005000
    6              .025                                                              00006000
    7                0.        0.                                                    00007000
    8              .025        0.                                                    00007010
    9              .050        0.                                                    00007020
   10              .075        0.                                                    00007030
   11              .100        0.                                                    00007040
   12              .125        0.                                                    00007050
   13              .150        0.                                                    00007060
   14              .175        0.                                                    00007070
   15              760.      0.50      2.40      1.50                                00008000
   16              760.      0.50      2.40      1.50                                00009000
   17              760.      0.50      2.40       3.0                                00010000
   18              550.     1300.     2250.    0.0403    0.1048    0.1613        0.  00011000
   19              12.5     -30.0      15.0      17.5     -10.0      15.0            00012000
   20              12.5     -10.0      15.0      12.5      10.0      15.0            00012010
   21              12.5      10.0      15.0      12.5      30.0      15.0            00012020
   22                0.                                                              00013000
   23                0.                                                              00014000
   24                0.                                                              00014010
   25                0.                                                              00014020
   26                0.                                                              00015000
   27                0.                                                              00016000
   28                0.                                                              00016010
   29                0.                                                              00016020
   30                0.        0.                                                    00017000
   31              0.18      0.25       0.0       0.0                                00018000
   32                0.        0.        0.        0.        0.        0.            00019000
   33              30.0        0.        0.        0.        0.        0.            00020000
   34               0.0       0.0                                                    00021000
   35             .0100      -6.0                                                    00021010
   36             .1550      -6.0                                                    00021020
   37             .1650       0.0                                                    00021030
   38              -16.      -16.       7.0      -16.       60.       32.      -20.  00022000
   39              -16.      -16.       7.0      -16.       60.       32.        0.  00022010
   40              -16.      -16.       7.0      -16.       60.       32.       20.  00022020
   41              10.0      12.0      8.00      16.0     15.15      20.0      39.0  00023000
   42                                                                                00024000
   43                                                                                00025000
   44                                                                                00026000
   45        20   27    2    4    2    2    8                                        00027000
   46         5    5                                                                 00028000
   47               0.0      45.0      20.0                                          00029000
   48             0.025      45.0      20.0                                          00029000
   49             0.050      45.0      20.0                                          00029010
   50             0.075      45.0      20.0                                          00029020
```

ECHO OF INPUT DATA IN CARD IMAGE FORMAT

```
                     1         2         3         4         5         6         7         8
LINE NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890
   51         0.100      45.0      20.0                                                    00029030
   52         0.125      45.0      20.0                                                    00029040
   53         0.150      45.0      20.0                                                    00029050
   54         0.175      45.0      20.0                                                    00029060
   55        1    20                                                                       00030000
   56        1    27                                                                       00031000
   57         0.025                                                                        00032000
   58        12024-T4 AL                                                                   00033000
   59      2.588E-4    10.5E6    44000.     4.9E5               62000.       0.3           00034000
   60        59000.    62000.       0.0       0.0                                          00035300
   61        24130 STEEL                                                                   00033010
   62      7.320E-4    29.0E6   163000.     6.0E6              180000.       0.3           00034010
   63       174000.    81000.                                                              00035010
   64        8    0    0.4347    0.3028    0.1514    0.1514                                00036000
   65           0.0     0.834     0.083                                                    00037000
   66        -0.590     0.590     0.083                                                    00037010
   67        -0.834       0.0     0.083                                                    00037020
   68        -0.590    -0.590     0.083                                                    00037030
   69           0.0    -0.834     0.083                                                    00037040
   70         0.590    -0.590     0.083                                                    00037050
   71         0.834       0.0     0.083                                                    00037060
   72         0.590     0.590     0.093                                                    00037070
   73        4    0    0.1081    0.1082    0.0723    0.0723                                00036100
   74        -0.593     0.593     0.065                                                    00037100
   75        -0.593    -0.593     0.065                                                    00037110
   76         0.593    -0.593     0.065                                                    00037120
   77         0.593     0.593     0.065                                                    00037130
   78        1              8.0     -10.0       0.0                                        00038010
   79        2             25.0     -10.0       0.0                                        00038020
   80        3              8.0      10.0       0.0                                        00038030
   81        4             25.0      10.0       0.0                                        00038040
   82        5             10.0     -30.0      12.0                                        00038050
   83        6             10.0     -10.0      12.0                                        00038060
   84        7             10.0      10.0      12.0                                        00038070
   85        8             10.0      30.0      12.0                                        00038080
   86        9             12.5     -30.0     12.33                                        00038090
   87       10             12.5     -10.0     12.33                                        00038100
   88       11             12.5      10.0     12.33                                        00038110
   89       12             12.5      30.0     12.33                                        00038120
   90       13             25.0     -30.0    14.108                                        00038130
   91       14             25.0     -10.0    14.108                                        00038140
   92       15             25.0      10.0    14.108                                        00038150
   93       16             25.0      30.0    14.108                                        00038160
   94       17            2.258     -30.0      39.0                                        00038170
   95       18            2.258     -10.0      39.0                                        00038180
   96       19            2.258      10.0      39.0                                        00038190
   97       20            2.258      30.0      39.0                                        00038200
   98       21             10.0     -40.0      12.0                                        00038210
   99       22             25.0     -40.0      14.0                                        00038220
  100        1    1    6                0    2    21    2    2                            00039001
  101        2    3    7                0    2    21    2    2                            00039002
```

ECHO OF INPUT DATA IN CARD IMAGE FORMAT

```
                     1         2         3         4         5         6         7         8
LINE NO.    12345678901234567890123456789012345678901234567890123456789012345678901234567890
     102        3    2   14              0    2   22    2    2                      00039003
     103        4    4   15              0    2   22    2    2                      00039004
     104        5    2    6              0    2   21    2    2  000  010  000  010  00039005
     105        6    4    7              0    2   21    2    2  000  010  000  010  00039006
     106        7    5    6              0    1   22    2    1                      00039007
     107        8    6    7              0    1   22    2    1                      00039008
     108        9    7    8              0    1   22    2    1                      00039009
     109       10   13   14              0    1   21    2    1                      00039010
     110       11   14   15              0    1   21    2    1                      00039011
     111       12   15   16              0    1   21    2    1                      00039012
     112       13    5    9              0    2   21    2    1                      00039013
     113       14    6   10              0    2   21    2    1                      00039014
     114       15    7   11              0    2   21    2    1                      00039015
     115       16    8   12              0    2   21    2    1                      00039016
     116       17    9   13              0    2   21    2    1                      00039017
     117       18   10   14              0    2   21    2    1                      00039018
     118       19   11   15              0    2   21    2    1                      00039019
     119       20   12   16              0    2   21    2    1                      00039020
     120       21    5   17              0    2   21    2    1                      00039021
     121       22    6   18              0    2   21    2    1                      00039022
     122       23    7   19              0    2   21    2    1                      00039023
     123       24    8   20              0    2   21    2    1                      00039024
     124       25   17   18              0    2   21    2    1                      00039025
     125       26   18   19              0    2   21    2    1                      00039026
     126       27   19   20              0    2   21    2    1                      00039027
     127        5    6   13   14    6    7   14   15    7    8   15   16            00040000
     128        5    6   17   18    6    7   18   19    7    8   19   20            00041000
     129        9   10   10   11   11   12                                          00042000
     130      1111001                                                              00043000
     131      2112001                                                              00044000
     132         -0.5                                                              00045000
     133      1111001                                                              00046000
     134      4111001                                                              00047000
```

THREE-PASSENGER TRANSPORT AIRCRAFT SEAT

SAMPLE CASE NO. 1

INPUT DATA

A 2-DIMENSIONAL SIMULATION OF A 3-PASSENGER SEAT WITH 3 OCCUPANTS

SIMULATION CONTROL DATA

TI=0.000000, TF =0.180000, DTI =0.000500, DMAX =0.000500, DMIN =0.000500
EUR =0.100000, ELR =0.001000

RESTART DATA TO BE WRITTEN ON UNIT 25 AT 0.025-SEC INTERVALS

ACCELERATION FILTER CLASSES

HEAD	CHEST	PELVIS	SEAT
1000	180	180	180

FORCE-DEFLECTION CHARACTERISTICS

SEAT CUSHION		BACK CUSHION		HEAD REST	
C	B	C	B	C	B
760.000	0.500	760.000	0.500	760.000	0.500

F2	D2	F3	D3	F4	D4
LAP BELT					
550.00	0.04030	1300.00	0.10480	2250.00	0.16130

XLB(1)	YLB(1)	ZLB(1)	XLB(2)	YLB(2)	ZLB(2)
12.500	-30.000	15.000	12.500	-10.000	15.000
12.500	-10.000	15.000	12.500	10.000	15.000
12.500	10.000	15.000	12.500	30.000	15.000

	DAMPING COEFFICIENT	THICKNESS/SLACK
SEAT CUSHION	2.40000	1.50000
BACK CUSHION	2.40000	1.50000
HEAD REST	2.40000	3.00000
LAP BELT	0.00000	0.00000

CRASH CONDITIONS

X	Y	Z	PITCH	ROLL	YAW
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

VX	VY	VZ	ANGVX	ANGVY	ANGVZ
30.00000	0.00000	0.00000	0.00000	0.00000	0.00000

T	AX	AY	AZ	ALFX	ALFY	ALFZ
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.01000	-6.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.15500	-6.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.16000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

OCCUPANT PROPERTIES---PASSENGER NO. 1

STATURE= 69.10 INCHES, WEIGHT= 164.00 POUNDS

SEGMENT	LENGTH	RHO	MASS	IX	IY	IZ
1	10.793	4.670	0.089544	2.320000	0.760000	2.320000
2	11.560	5.550	0.093168	2.180000	0.926000	1.700000
3	8.350	6.330	0.026139	0.275000	0.266000	0.233000
4	11.300	4.720	0.012552	0.132000	0.135000	0.022000
5	11.300	6.260	0.012552	0.017000	0.185000	0.195000
6	11.300	4.720	0.012552	0.132000	0.135000	0.022000
7	11.300	6.260	0.012552	0.017000	0.185000	0.195000
8	16.500	8.350	0.056159	0.127000	1.220000	0.873000
9	18.000	11.000	0.024560	0.927000	0.994000	0.505000
10	16.500	8.350	0.056159	0.127000	1.220000	0.673000
11	18.000	11.000	0.024560	0.927000	0.994000	0.505000
12	4.880	2.440	0.005124		0.017700	

CONTACT SURFACE RADII

SEGMENT	RADIUS
1	4.50
2	4.50
3	3.44
4	1.95
5	1.85
6	1.95
7	1.85
8	3.10
9	2.30
10	3.10
11	2.30
12	2.30
13	2.30
14	1.60
15	1.60
16	3.56
17	3.56
18	2.61
19	2.61
20	1.85
21	1.85
22	2.34
23	2.34

SPINAL PROPERTIES

	COEFFICIENT C	EXP COEFF B	DAMPING
LUMBAR SPINE - AXIAL	5000.000	0.200	2.000
LUMBAR SPINE - FLEXURAL	1000.000	2.000	200.000
NECK - AXIAL	3240.000	0.300	5.000
NECK - FLEXURAL	60000.000	0.080	50.000

OCCUPANT PROPERTIES--PASSENGER NO. 2

STATURE= 69.10 INCHES, WEIGHT= 164.00 POUNDS

SEGMENT	LENGTH	RHO	MASS	IX	IY	IZ
1	10.793	4.670	0.085544	2.320000	0.760000	2.320000
2	11.560	6.550	0.093168	2.180000	0.926000	1.700000
3	8.350	6.330	0.026139	0.275000	0.266000	0.233000
4	11.300	4.720	0.012552	0.132000	0.135000	0.022000
5	13.300	6.260	0.012552	0.017000	0.185000	0.195000
6	11.300	4.720	0.012552	0.132000	0.135000	0.022000
7	13.300	6.260	0.012552	0.017000	0.185000	0.195000
8	16.500	8.350	0.056159	0.127000	1.220000	0.873000
9	18.000	11.000	0.024560	0.927000	0.994000	0.505000
10	16.500	8.350	0.056159	0.127000	1.220000	0.873000
11	18.000	11.000	0.024560	0.927000	0.994000	0.505000
12	4.880	2.440	0.005124		0.017700	

CONTACT SURFACE RADII

SEGMENT	RADIUS
1	4.50
2	4.50
3	3.44
4	1.95
5	1.85
6	1.95
7	1.85
8	3.10
9	2.30
10	3.10
11	2.30
12	2.30
13	2.30
14	1.60
15	1.60
16	3.56
17	3.56
18	2.61
19	2.61
20	1.85
21	1.85
22	2.34
23	2.34

SPINAL PROPERTIES

	COEFFICIENT C	EXP COEFF B	DAMPING
LUMBAR SPINE - AXIAL	5000.000	0.200	2.000
LUMBAR SPINE - FLEXURAL	1000.000	2.000	200.000
NECK - AXIAL	3240.000	0.300	5.000
NECK - FLEXURAL	60000.000	0.080	50.000

OCCUPANT PROPERTIES---PASSENGER NO. 3

STATURE= 69.10 INCHES, WEIGHT= 164.00 POUNDS

SEGMENT	LENGTH	RHO	MASS	IX	IY	IZ
1	10.793	4.670	0.089544	2.320000	0.760000	2.320000
2	11.560	6.550	0.093168	2.180000	0.926000	1.700000
3	9.350	6.330	0.026139	0.275000	0.266000	0.233000
4	11.300	4.720	0.012552	0.132000	0.135000	0.022000
5	13.300	6.260	0.012552	0.017000	0.185000	0.195000
6	11.300	4.720	0.012552	0.132000	0.135000	0.022000
7	13.300	6.260	0.012552	0.017000	0.185000	0.195000
8	16.500	8.350	0.056159	0.127000	1.220000	0.873000
9	18.000	11.000	0.024560	0.927000	0.994000	0.505000
10	16.500	8.350	0.056159	0.127000	1.220000	0.873000
11	18.000	11.000	0.024560	0.927000	0.994000	0.505000
12	4.880	2.440	0.005124		0.017700	

CONTACT SURFACE RADII

SEGMENT	RADIUS
1	4.50
2	4.50
3	3.44
4	1.95
5	1.85
6	1.95
7	1.85
8	3.10
9	2.30
10	3.10
11	2.30
12	2.30
13	2.30
14	1.60
15	1.60
16	2.56
17	2.56
18	2.61
19	2.61
20	1.85
21	1.85
22	2.34
23	2.34

SPINAL PROPERTIES

	COEFFICIENT C	EXP COEFF B	DAMPING
LUMBAR SPINE - AXIAL	5000.000	0.200	2.000
LUMBAR SPINE - FLEXURAL	1000.000	2.000	200.000
NECK - AXIAL	3240.000	0.300	5.000
NECK - FLEXURAL	60000.000	0.080	50.000

SEAT DESIGN DATA

```
XSEAT=  10.0000    ZSEAT=  12.0000    ANGSP=    8.0000    ANGSB=  16.0000
XL    =  15.1500   XW    =  20.0000   SBHT =  39.0000     SBW   =  20.0000

    NUMBER OF NODES            20
    NUMBER OF ELEMENTS         27
    NUMBER OF MATERIALS         2
    NO. OF DISP. NODES          5
    NO. OF COORD NODES          2
    NO. OF BEAM XSECT           2
```

MATERIAL DATA

```
     MATERIAL NAME                          2024-T4 AL
     MATERIAL NO                             1
     FIRST YIELD STRESS                    0.44000E+05
     SECOND YIELD STRESS                   0.58000E+05
     ULTIMATE STRESS                       0.62000E+05
     MODULUS OF ELASTICITY                 0.10500E+08
     FIRST PLASTIC MODULUS                 0.49000E+06
     SECOND PLASTIC MODULUS                0.62000E+05
     POISSONS RATIO                        0.30000E+00


     MATERIAL NAME                          4130 STEEL
     MATERIAL NO                             2
     FIRST YIELD STRESS                    0.16300E+06
     SECOND YIELD STRESS                   0.17400E+06
     ULTIMATE STRESS                       0.18000E+06
     MODULUS OF ELASTICITY                 0.29000E+08
     FIRST PLASTIC MODULUS                 0.60000E+07
     SECOND PLASTIC MODULUS                0.81000E+05
     POISSONS RATIO                        0.30000E+00
```

BEAM CROSS-SECTION DATA

N	NSEG	KLOS	ABM	FIXX	FIYY	FIZZ	TORCON
1	8	0	0.00000E+00	0.30280E+00	0.15140E+00	0.15140E+00	0.14225E-01

I	Y	Z	XLEN	T
1	0.00E+00	0.83E+00	0.64E+00	0.83E-01
2	-0.59E+00	0.59E+00	0.64E+00	0.83E-01
3	-0.83E+00	0.00E+00	0.64E+00	0.83E-01
4	-0.59E+00	-0.59E+00	0.64E+00	0.83E-01
5	0.00E+00	-0.83E+00	0.64E+00	0.83E-01
6	0.59E+00	-0.59E+00	0.64E+00	0.83E-01
7	0.83E+00	0.00E+00	0.64E+00	0.83E-01
8	0.59E+00	0.59E+00	0.64E+00	0.83E-01

N	NSEG	KLOS	ABM	FIXX	FIYY	FIZZ	TORCON
2	4	0	0.00000E+00	0.10820E+00	0.72300E-01	0.72300E-01	0.91565E-01

I	Y	Z	XLEN	T
1	-0.59E+00	0.59E+00	0.12E+01	0.65E-01
2	-0.59E+00	-0.59E+00	0.12E+01	0.65E-01
3	0.59E+00	-0.59E+00	0.12E+01	0.65E-01
4	0.59E+00	0.59E+00	0.12E+01	0.65E-01

NODE NO.	X	Y	Z
1	8.00000	-10.00000	0.00000
2	25.00000	-10.00000	0.00000
3	8.00000	10.00000	0.00000
4	25.00000	10.00000	0.00000
5	10.00000	-30.00000	12.00000
6	10.00000	-10.00000	12.00000
7	10.00000	10.00000	12.00000
8	10.00000	30.00000	12.00000
9	12.50000	-30.00000	12.33000
10	12.50000	-10.00000	12.33000
11	12.50000	10.00000	12.33000
12	12.50000	30.00000	12.33000
13	25.00000	-30.00000	14.10800
14	25.00000	-10.00000	14.10800
15	25.00000	10.00000	14.10800
16	25.00000	30.00000	14.10800
17	2.25800	-30.00000	39.00000
18	2.25800	-10.00000	39.00000
19	2.25800	10.00000	39.00000
20	2.25800	30.00000	39.00000
21	10.00000	-40.00000	12.00000
22	25.00000	-40.00000	14.00000

ELEMENT NO.	N1	N2	N3	N4	N5	N6	N7	N8	MTYP				
1	1	5	1	6	0	2	21	2	2	0	0	0	0
2	3	7	3	7	0	2	21	2	2	0	0	0	0
3	2	14	2	14	0	2	22	2	2	0	0	0	0
4	4	15	4	15	0	2	22	2	2	0	0	0	0
5	2	6	2	6	0	2	21	2	2	0	10	0	10
6	4	7	4	7	0	2	21	2	2	0	10	0	10
7	5	6	5	6	0	1	22	2	1	0	0	0	0
8	6	7	6	7	0	1	22	2	1	0	0	0	0
9	7	8	7	8	0	1	22	2	1	0	0	0	0
10	13	14	13	14	0	1	21	2	1	0	0	0	0
11	14	15	14	15	0	1	21	2	1	0	0	0	0
12	15	16	15	16	0	1	21	2	1	0	0	0	0
13	5	9	5	9	0	2	21	2	1	0	0	0	0
14	6	10	6	10	0	2	21	2	1	0	0	0	0
15	7	11	7	11	0	2	21	2	1	0	0	0	0
16	8	12	8	12	0	2	21	2	1	0	0	0	0
17	9	13	9	13	0	2	21	2	1	0	0	0	0
18	10	14	10	14	0	2	21	2	1	0	0	0	0
19	11	15	11	15	0	2	21	2	1	0	0	0	0
20	12	16	12	16	0	2	21	2	1	0	0	0	0
21	5	17	5	17	0	2	21	2	1	0	0	0	0
22	6	18	6	18	0	2	21	2	1	0	0	0	0

```
 23        7   19    7   19        0   2  21   2   1   0   0   0   0
 24        8   20    8   20        0   2  21   2   1   0   0   0   0
 25       17   [illegible]   17   18        0   2  21   2   1   0   0   0   0
 26       18   [illegible]   18   19        0   2  21   2   1   0   0   0   0
 27       19   20   19   20        0   2  21   2   1   0   0   0   0

SEAT PAN NODES =    5   6  13  14   6   7  14  15   7   8  15  16

SEAT BACK NODES =    5   6  17  18   6   7  18  19   7   8  19  20

LAP BELT ANCHOR NODES =    9  10  10  11  11  12

DISPLACEMENT NODES

          NODE  CONDITION
   1        1     1 1 1 0 0 1
   2        2     1 1 2 0 0 1
                     -0.5000
   3        3     1 1 1 0 0 1
   4        4     1 1 1 0 0 1


      STRESS AND BAR STORAGE   LSTRS 1056   LBAR  648


   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357

   NUD        77          SIZE OF STIFF      6357
```

INITIAL CONDITIONS---PASSENGER NO. 1

SEGMENT	ANGLE
1	-14.799
2	-14.799
3	8.201
4	-16.000
5	60.000
6	-16.000
7	60.000
8	-5.393
9	-2.144
10	-5.393
11	-2.144

GENERALIZED COORDINATES---PASSENGER NO. 1

J	Q(J)	QD(J)	QDD(J)
1	0.13707E+02	0.36000E+03	0.00000E+00
2	0.22552E+02	0.00000E+00	0.00000E+00
3	-0.25829E+00	0.00000E+00	0.00000E+00
4	0.10850E+02	0.00000E+00	0.00000E+00
5	-0.25829E+00	0.00000E+00	0.00000E+00
6	0.63300E+01	0.00000E+00	0.00000E+00
7	0.14314E+00	0.00000E+00	0.00000E+00
8	-0.27925E+00	0.00000E+00	0.00000E+00
9	0.24435E+00	0.00000E+00	0.00000E+00
10	-0.98123E-01	0.00000E+00	0.00000E+00
11	-0.37525E-01	0.00000E+00	0.00000E+00

INITIAL CONDITIONS---PASSENGER NO. 2

SEGMENT	ANGLE
1	-15.399
2	-15.399
3	7.601
4	-16.000
5	60.000
6	-16.000
7	60.000
8	-4.639
9	-2.950
10	-4.639
11	-2.950

GENERALIZED COORDINATES---PASSENGER NO. 2

J	Q(J)	QD(J)	QDD(J)
12	0.13388E+02	0.36000E+03	0.00000E+00
13	0.22744E+02	0.00000E+00	0.00000E+00
14	-0.26876E+00	0.00000E+00	0.00000E+00
15	0.10850E+02	0.00000E+00	0.00000E+00
16	-0.26876E+00	0.00000E+00	0.00000E+00
17	0.63300E+01	0.00000E+00	0.00000E+00
18	0.13267E+00	0.00000E+00	0.00000E+00
19	-0.27325E+00	0.00000E+00	0.00000E+00
20	0.24935E+00	0.00000E+00	0.00000E+00
21	-0.80966E-01	0.00000E+00	0.00000E+00
22	-0.51483E-01	0.00000E+00	0.00000E+00

INITIAL CONDITIONS---PASSENGER NO. 3

SEGMENT	ANGLE
1	-15.939
2	-15.939
3	7.061
4	-16.000
5	60.000
6	-16.000
7	60.000
8	-3.873
9	-3.772
10	-3.873
11	-3.772

GENERALIZED COORDINATES---PASSENGER NO. 3

J	Q(J)	QD(J)	QDD(J)
23	0.13071E+02	0.36000E+03	0.00000E+00
24	0.22937E+02	0.00000E+00	0.00000E+00
25	-0.27818E+00	0.00000E+00	0.00000E+00
26	0.10050E+02	0.00000E+00	0.00000E+00
27	-0.27818E+00	0.00000E+00	0.00000E+00
28	0.63300E+01	0.00000E+00	0.00000E+00
29	0.12324E+00	0.00000E+00	0.00000E+00
30	-0.27925E+00	0.00000E+00	0.00000E+00
31	0.24435E+00	0.00000E+00	0.00000E+00
32	-0.67590E-01	0.00000E+00	0.00000E+00
33	-0.65837E-01	0.00000E+00	0.00000E+00

MUD 77 SIZE OF STIFF 6357

NODAL DISPLACEMENT VECTOR (TIME = 0.025 SEC)

NODE	TRANSLATION X	Y	Z
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	-0.5000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.4372	-0.1288	-0.2000
6	0.3601	-0.1287	-0.0639
7	0.0032	-0.1283	0.0004
8	0.0477	-0.1293	0.2597
9	0.4474	-0.1272	-0.2831
10	0.3680	-0.1291	-0.1376
11	0.0042	-0.1337	0.0015
12	0.0487	-0.1363	0.2538
13	0.5016	-0.1467	-0.7019
14	0.4053	-0.1478	-0.5053
15	0.0090	-0.1567	-0.0007
16	0.0524	-0.1577	0.2290
17	1.4124	-0.3918	0.0780
18	0.9595	-0.3908	0.1071
19	0.5817	-0.3909	0.1648
20	0.2270	-0.3896	0.3172

SUPPORT STRUCTURE REACTIONS (TIME = 0.025 SEC)

NODE	FX	FY	FZ	MX	MY	MZ
1	-109.	-864.	-2247.	0.	0.	355.
2	-2098.	862.	-2247.	0.	0.	3786.
3	199.	-965.	3661.	0.	0.	11.
4	3533.	954.	-3726.	0.	0.	3325.

BEAM ELEMENT LOADS (TIME = 0.025 SEC)

BEAM	NODE	FX	FY	FZ	MX	MY	MZ	STATUS
1	1	2217.	-397.	-304.	-349.	6.	69.	0
	6	-2215.	897.	304.	349.	3687.	-10977.	0
2	3	-3653.	-308.	446.	-11.	0.	2.	0
	7	3654.	308.	-446.	11.	-5424.	-11052.	0
3	2	-895.	768.	7.	-706.	348.	2348.	0
	14	895.	-768.	-7.	706.	-443.	8489.	0
4	4	897.	864.	-5.	-218.	371.	2538.	0
	15	-897.	-864.	5.	218.	-294.	9652.	0
5	2	-2768.	122.	0.	-173.	0.	-3816.	0
	6	2768.	-122.	0.	173.	0.	6159.	0
6	4	4549.	50.	0.	49.	0.	-4024.	0
	7	-4549.	-50.	0.	-49.	0.	4981.	0

7	5	-186.	67.	-195.	16.	397.	1559.	0
	6	186.	-67.	195.	-16.	3493.	189.	0
8	6	-147.	1055.	-463.	173.	4553.	10533.	1
	7	92.	-1055.	463.	-173.	4697.	10576.	1
9	7	196.	34.	-175.	-13.	3346.	-335.	0
	8	-196.	-34.	175.	13.	162.	1015.	0
10	13	262.	14.	-8.	26.	-335.	-1667.	0
	14	-262.	-14.	8.	-26.	499.	1944.	0
11	14	134.	-795.	-766.	162.	7692.	-7730.	1
	15	-63.	795.	766.	-162.	7630.	-8162.	1
12	15	-158.	115.	-39.	-6.	770.	3251.	0
	16	158.	-115.	39.	6.	2.	-346.	0
13	5	-126.	-209.	88.	-152.	-57.	-2166.	0
	9	126.	209.	-88.	152.	-165.	1639.	0
14	6	1095.	-648.	169.	-83.	-202.	-4861.	1
	10	-5275.	648.	-169.	83.	-224.	3228.	1
15	7	-2496.	-575.	346.	-35.	-1491.	-4335.	1
	11	4435.	575.	-346.	35.	619.	2885.	0
16	8	7.	-198.	36.	-14.	656.	-1626.	0
	12	-7.	198.	-36.	14.	-748.	1126.	0
17	9	-23.	-264.	0.	-119.	153.	-1641.	0
	13	23.	264.	0.	119.	-147.	-1689.	0
18	10	5552.	-575.	-24.	-11.	222.	-3228.	1
	14	-806.	675.	24.	11.	85.	-5288.	1
19	11	-4142.	-614.	65.	26.	-629.	-2883.	0
	15	943.	614.	-65.	-26.	-197.	-4864.	0
20	12	110.	-165.	-50.	12.	731.	-1136.	0
	16	-110.	165.	50.	-12.	-96.	-941.	0
21	5	-154.	30.	-24.	-570.	-128.	94.	0
	17	154.	-30.	24.	570.	805.	740.	0
22	6	-11.	-17.	209.	-539.	-4641.	-116.	0
	18	-428.	17.	-209.	539.	-1231.	-369.	0
23	7	-19.	-25.	-234.	-506.	5478.	30.	1
	19	403.	25.	234.	506.	1097.	-729.	0
24	8	128.	12.	54.	-513.	-814.	-169.	0
	20	-128.	-12.	-54.	513.	-693.	506.	0
25	17	-31.	155.	-4.	750.	695.	690.	0
	18	31.	-155.	4.	-750.	-608.	2412.	0
26	18	5.	-293.	-152.	-431.	1275.	-2895.	0
	19	-5.	293.	152.	431.	1765.	-2962.	0

27	19	7.	131.	47.	735.	-1473.	2203.	0
	20	-7.	-131.	-47.	-735.	536.	415.	0

S T R E S S E S   I N   B E A M   E L E M E N T S   (TIME = 0.025 SEC)

BEAM NO	NODE NO	S-MAX	S-MIN
1	1	0.000000E+00	-0.779896E+04
	6	0.113110E+06	-0.127474E+06
2	3	0.118645E+05	0.000000E+00
	7	0.147002E+06	-0.123302E+06
3	2	0.250234E+05	-0.192190E+05
	14	0.761758E+05	-0.703713E+05
4	4	0.209496E+05	-0.267656E+05
	15	0.786789E+05	-0.844943E+05
5	2	0.402822E+05	-0.223301E+05
	6	0.594955E+05	-0.415433E+05
6	4	0.182557E+05	-0.477610E+05
	7	0.261102E+05	-0.556155E+05
7	5	0.102098E+05	-0.933280E+04
	6	0.223276E+05	-0.214505E+05
8	6	0.580011E+05	-0.580033E+05
	7	0.582291E+05	-0.580461E+05
9	7	0.205052E+05	-0.214289E+05
	8	0.590019E+04	-0.682392E+04
10	13	0.982379E+04	-0.110606E+05
	14	0.115645E+05	-0.128013E+05
11	14	0.565551E+05	-0.573068E+05
	15	0.586351E+05	-0.588261E+05
12	15	0.207429E+05	-0.199971E+05
	16	0.630044E+04	-0.555473E+04
13	5	0.186484E+05	-0.178308E+05
	9	0.152021E+05	-0.143844E+05
14	6	0.376745E+05	-0.453889E+05
	10	0.124117E+05	-0.442189E+05
15	7	0.486532E+05	-0.469325E+05
	11	0.421831E+05	-0.153125E+05
16	8	0.186982E+05	-0.107443E+05
	12	0.153460E+05	-0.153921E+05

17	9	0.147887E+05	-0.146418E+05
	13	0.151391E+05	-0.149922E+05
18	10	0.119545E+05	-0.446506E+05
	14	0.421028E+05	-0.460574E+05
19	11	0.411294E+05	-0.164893E+05
	15	0.432040E+05	-0.403123E+05
20	12	0.149651E+05	-0.156792E+05
	16	0.815215E+04	-0.886621E+04
21	5	0.232199E+04	-0.132635E+04
	17	0.131729E+05	-0.121770E+05
22	6	0.390649E+05	-0.389870E+05
	18	0.117328E+05	-0.145089E+05
23	7	0.452477E+05	-0.451278E+05
	19	0.162907E+05	-0.136746E+05
24	8	0.765363E+04	-0.848315E+04
	20	0.942085E+04	-0.102504E+05
25	17	0.114572E+05	-0.112561E+05
	18	0.248768E+05	-0.246757E+05
26	18	0.341899E+05	-0.342220E+05
	19	0.387627E+05	-0.387947E+05
27	19	0.301335E+05	-0.301791E+05
	20	0.777792E+04	-0.782352E+04

RESTART DATA WRITTEN AT T = 0.250000E-01 SEC

RESTART DATA WRITTEN AT T = 0.500000E-01 SEC

RESTART DATA WRITTEN AT T = 0.750000E-01 SEC

RESTART DATA WRITTEN AT T = 0.100000E+00 SEC

RESTART DATA WRITTEN AT T = 0.125000E+00 SEC

RESTART DATA WRITTEN AT T = 0.150000E+00 SEC

N O D A L   D I S P L A C E M E N T   V E C T O R   (TIME = 0.175 SEC)

NODE	TRANSLATION X	Y	Z
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	-0.5000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.5634	-0.0974	-0.0589
6	0.3662	-0.0963	-0.0617
7	0.0066	-0.0917	0.0021
8	0.3994	-0.0988	0.4380
9	0.5809	-0.0980	-0.2210
10	0.3748	-0.1088	-0.1259
11	0.0081	-0.1178	0.0030
12	0.4089	-0.1376	0.3570
13	0.6798	-0.2091	-1.1737
14	0.4057	-0.2224	-0.5082
15	0.0152	-0.2325	-0.0032
16	0.4694	-0.2387	-0.1472
17	2.0783	-0.4063	0.3467
18	1.4623	-0.4100	0.2353
19	1.1740	-0.4092	0.3147
20	1.1837	-0.4070	0.6563

S U P P O R T   S T R U C T U R E   R E A C T I O N S   (TIME = 0.175 SEC)

NODE	FX	FY	FZ	MX	MY	MZ
1	238.	-917.	-110.	735.	-1473.	744.
2	-920.	997.	-110.	735.	-1473.	6052.
3	477.	-740.	5053.	735.	-1473.	-1259.
4	4159.	652.	-5237.	735.	-1473.	57.

B E A M   E L E M E N T   L O A D S   (TIME = 0.175 SEC)

BEAM	NODE	FX	FY	FZ	MX	MY	MZ	STATUS
1	1	55.	-925.	-227.	-730.	10.	144.	0
	6	-50.	925.	227.	730.	2751.	-11395.	0
2	3	-5068.	-688.	389.	1242.	-17.	-207.	0
	7	5067.	688.	-389.	-1242.	-4716.	-8157.	0
3	2	352.	741.	21.	-1740.	235.	1046.	0
	14	-353.	-741.	-21.	1740.	-537.	5410.	0
4	4	1884.	458.	44.	1425.	165.	1324.	0
	15	-1882.	-458.	-44.	-1425.	-786.	5132.	0
5	2	-1163.	257.	0.	-713.	0.	-2392.	0
	5	1162.	-257.	0.	713.	0.	7330.	0
6	4	5392.	139.	0.	113.	0.	-1991.	0
	7	-5393.	-139.	0.	-113.	0.	4663.	0

7	5	-337.	196.	-403.	167.	2574.	2613.	0
	6	337.	-196.	403.	-167.	5482.	1301.	0
8	6	-470.	1045.	-421.	191.	4138.	10422.	1
	7	68.	-1045.	421.	-191.	4287.	10476.	1
9	7	39.	-210.	2.	-180.	1305.	-3296.	0
	8	-39.	210.	-2.	180.	-1349.	-908.	0
10	13	544.	-216.	-214.	284.	469.	-4101.	0
	14	-544.	216.	214.	-284.	3814.	-222.	0
11	14	425.	-800.	-624.	157.	5652.	-7242.	1
	15	-86.	800.	624.	-157.	6819.	-8754.	1
12	15	144.	352.	241.	-231.	-3393.	5815.	0
	16	-144.	-352.	-241.	231.	-1427.	1232.	0
13	5	-324.	-294.	290.	-1505.	755.	-4092.	0
	9	512.	294.	-290.	1505.	-1936.	3351.	0
14	6	-389.	-601.	775.	-691.	-831.	-4726.	1
	10	-2091.	601.	-775.	691.	-1323.	3210.	0
15	7	-3318.	-339.	904.	218.	-2285.	-3357.	1
	11	6098.	339.	-904.	-218.	5.	2501.	0
16	8	-271.	-39.	210.	1371.	1638.	310.	0
	12	271.	39.	-210.	-1371.	-2168.	-409.	0
17	9	176.	-574.	-106.	-1475.	1431.	-3381.	0
	13	-176.	574.	106.	1475.	-97.	-3863.	0
18	10	3619.	-669.	-79.	-631.	1103.	-3221.	0
	14	-584.	669.	79.	631.	-106.	-5231.	1
19	11	-4484.	-518.	-8.	276.	-6.	-2499.	0
	15	1284.	518.	8.	-276.	113.	-4035.	0
20	12	359.	131.	-201.	1402.	2179.	411.	0
	16	-359.	-131.	201.	-1402.	359.	1240.	0
21	5	-89.	-9.	20.	-770.	-1027.	-381.	0
	17	89.	9.	-20.	770.	479.	128.	0
22	6	-73.	-72.	162.	-582.	-3366.	-961.	0
	18	-366.	72.	-162.	582.	-1191.	-1071.	0
23	7	-20.	-24.	-253.	-324.	5572.	12.	1
	19	423.	24.	253.	324.	1534.	-680.	0
24	8	144.	28.	84.	-396.	-1421.	46.	0
	20	-144.	-28.	-84.	396.	-941.	730.	0
25	17	11.	84.	-33.	476.	782.	32.	0
	18	-11.	-84.	33.	-476.	-114.	1648.	0
26	18	99.	-296.	-138.	-567.	673.	-2878.	0
	19	-20.	296.	138.	567.	2077.	-3038.	0

27	19	19.	149.	77.	1004.	-1967.	2364.	0
	20	-19.	-149.	-77.	-1004.	431.	617.	0

S T R E S S E S I N B E A M E L E M E N T S (TIME = 0.175 SEC)

BEAM NO	NODE NO	S-MAX	S-MIN
1	1	0.109133E+04	-0.144494E+04
	6	0.115876E+06	-0.116204E+06
2	3	0.182745E+05	0.000000E+00
	7	0.122020E+06	-0.891810E+05
3	2	0.938852E+04	-0.116715E+05
	14	0.804597E+05	-0.827471E+05
4	4	0.610295E+04	-0.183253E+05
	15	0.424345E+05	-0.546420E+05
5	2	0.233968E+05	-0.158539E+05
	6	0.638980E+05	-0.563617E+05
6	4	0.000000E+00	-0.338181E+05
	7	0.207611E+05	-0.557382E+05
7	5	0.237840E+05	-0.221949E+05
	6	0.351456E+05	-0.335589E+05
8	6	0.579469E+05	-0.580432E+05
	7	0.574655E+05	-0.578755E+05
9	7	0.205560E+05	-0.207407E+05
	8	0.990945E+04	-0.100942E+05
10	13	0.244128E+05	-0.269806E+05
	14	0.226154E+05	-0.251819E+05
11	14	0.520457E+05	-0.541720E+05
	15	0.589124E+05	-0.588963E+05
12	15	0.404739E+05	-0.411551E+05
	16	0.114472E+05	-0.121289E+05
13	5	0.398255E+05	-0.396844E+05
	9	0.397536E+05	-0.396131E+05
14	6	0.439249E+05	-0.472383E+05
	10	0.328770E+05	-0.382082E+05
15	7	0.470146E+05	-0.455484E+05
	11	0.410765E+05	-0.166556E+04
16	8	0.168631E+05	-0.151057E+05
	12	0.220244E+05	-0.202669E+05

17	9	0.393035E+05	-0.396342E+05
	13	0.323204E+05	-0.326516E+05
18	10	0.308640E+05	-0.400739E+05
	14	0.418147E+05	-0.457517E+05
19	11	0.361073E+05	-0.712690E+04
	15	0.400386E+05	-0.298550E+05
20	12	0.200819E+05	-0.224118E+05
	16	0.119477E+05	-0.142770E+05
21	5	0.118363E+05	-0.112621E+05
	17	0.527255E+04	-0.469783E+04
22	6	0.357392E+05	-0.352600E+05
	19	0.173646E+05	-0.197400E+05
23	7	0.458667E+05	-0.457345E+05
	19	0.195272E+05	-0.167822E+05
24	8	0.115693E+05	-0.125013E+05
	20	0.132370E+05	-0.141697E+05
25	17	0.664282E+04	-0.671555E+04
	18	0.144116E+05	-0.144844E+05
26	18	0.289080E+05	-0.294477E+05
	19	0.421504E+05	-0.417673E+05
27	19	0.354630E+05	-0.355880E+05
	20	0.853431E+04	-0.865938E+04

RESTART DATA WRITTEN AT T = 0.175000E+00 SEC

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	PELVIS X (IN)	PELVIS Y (IN)	PELVIS Z (IN)	CHEST X (IN)	CHEST Y (IN)	CHEST Z (IN)
0.000	13.37	-0.14	22.74	10.51	-0.14	33.20
0.004	13.39	-0.14	22.75	10.51	-0.14	33.20
0.008	13.41	-0.14	22.76	10.54	-0.14	33.20
0.012	13.45	-0.14	22.76	10.60	-0.14	33.19
0.016	13.53	-0.14	22.77	10.68	-0.14	33.18
0.020	13.63	-0.14	22.77	10.80	-0.14	33.17
0.024	13.77	-0.14	22.76	10.94	-0.14	33.16
0.028	13.93	-0.14	22.74	11.11	-0.14	33.14
0.032	14.10	-0.14	22.70	11.32	-0.14	33.13
0.036	14.30	-0.14	22.65	11.55	-0.14	33.11
0.040	14.50	-0.14	22.58	11.82	-0.14	33.09
0.044	14.71	-0.14	22.50	12.13	-0.14	33.06
0.048	14.92	-0.14	22.42	12.47	-0.14	33.03
0.052	15.12	-0.14	22.35	12.84	-0.14	32.98
0.056	15.31	-0.14	22.28	13.13	-0.14	32.90
0.060	15.49	-0.14	22.22	13.52	-0.14	32.84
0.064	15.66	-0.14	22.17	13.93	-0.14	32.78
0.068	15.82	-0.14	22.12	14.35	-0.14	32.72
0.072	15.96	-0.14	22.09	14.79	-0.14	32.68
0.076	16.10	-0.14	22.07	15.25	-0.14	32.66
0.080	16.22	-0.14	22.06	15.73	-0.14	32.66
0.084	16.34	-0.14	22.07	16.22	-0.14	32.68
0.088	16.46	-0.14	22.09	16.74	-0.14	32.73
0.092	16.58	-0.14	22.13	17.28	-0.14	32.80
0.096	16.71	-0.14	22.18	17.85	-0.14	32.88
0.100	16.83	-0.14	22.26	18.45	-0.14	32.97
0.104	16.97	-0.14	22.34	19.08	-0.14	33.06
0.108	17.11	-0.14	22.44	19.73	-0.14	33.14
0.112	17.27	-0.14	22.53	20.41	-0.14	33.21
0.116	17.43	-0.14	22.63	21.11	-0.14	33.25
0.120	17.61	-0.14	22.73	21.82	-0.14	33.26
0.124	17.79	-0.14	22.80	22.54	-0.14	33.22
0.128	17.98	-0.14	22.87	23.27	-0.14	33.13
0.132	18.18	0.14	22.91	23.98	-0.14	32.97
0.136	18.39	-0.14	22.93	24.69	-0.14	32.76
0.140	18.59	-0.14	22.92	25.37	-0.14	32.48
0.144	18.79	-0.14	22.87	26.03	-0.14	32.13
0.148	18.99	-0.14	22.78	26.65	-0.14	31.72
0.152	19.17	-0.14	22.65	27.23	-0.14	31.25
0.156	19.35	-0.14	22.48	27.76	-0.14	30.73
0.160	19.51	-0.14	22.29	28.25	-0.14	30.14
0.164	19.64	-0.14	22.07	28.59	-0.14	29.60
0.168	19.74	-0.14	21.85	28.88	-0.14	29.02
0.172	19.80	-0.14	21.62	29.08	-0.14	28.42
0.176	19.84	-0.14	21.41	29.21	-0.14	27.83
0.180	19.86	-0.14	21.24	29.30	-0.14	27.25

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	PELVIS		CHEST	
(SEC)	PITCH (DEG) --	ROLL (DEG)	PITCH (DEG) --	ROLL (DEG)
0.000	-15.939	0.00	-15.94	0.00
0.004	-15.921	0.00	-15.95	0.00
0.008	-15.837	0.00	-15.97	0.00
0.012	-15.848	0.00	-15.98	0.00
0.016	-15.806	0.00	-15.97	0.00
0.020	-15.775	0.00	-15.93	0.00
0.024	-15.753	0.00	-15.84	0.00
0.028	-15.706	0.00	-15.71	0.00
0.032	-15.583	0.00	-15.53	0.00
0.036	-15.352	0.00	-15.30	0.00
0.040	-14.992	0.00	-15.01	0.00
0.044	-14.481	0.00	-14.63	0.00
0.048	-13.801	0.00	-14.16	0.00
0.052	-12.940	0.00	-13.58	0.00
0.056	-11.890	0.00	-12.89	0.00
0.060	-10.648	0.00	-12.06	0.00
0.064	-9.219	0.00	-11.08	0.00
0.068	-7.607	0.00	-9.93	0.00
0.072	-5.825	0.00	-8.61	0.00
0.076	-3.893	0.00	-7.11	0.00
0.080	-1.831	0.00	-5.43	0.00
0.084	0.343	0.00	-3.57	0.00
0.088	2.615	0.00	-1.55	0.00
0.092	4.971	0.00	0.63	0.00
0.096	7.400	0.00	2.95	0.00
0.100	9.890	0.00	5.41	0.00
0.104	12.434	0.00	7.97	0.00
0.108	15.023	0.00	10.64	0.00
0.112	17.647	0.00	13.38	0.00
0.116	20.298	0.00	16.18	0.00
0.120	22.964	0.00	19.02	0.00
0.124	25.635	0.00	21.89	0.00
0.128	28.301	0.00	24.78	0.00
0.132	30.961	0.00	27.65	0.00
0.136	33.618	0.00	30.51	0.00
0.140	36.264	0.00	33.34	0.00
0.144	38.882	0.00	36.14	0.00
0.148	41.443	0.00	38.90	0.00
0.152	43.849	0.00	41.65	0.00
0.156	45.920	0.00	44.48	0.00
0.160	47.523	0.00	47.43	0.00
0.164	48.644	0.00	50.48	0.00
0.168	49.374	0.00	53.54	0.00
0.172	49.847	0.00	56.56	0.00
0.176	50.201	0.00	59.51	0.00
0.180	50.624	0.00	62.38	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	HEAD			NECK		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	10.13	-0.14	45.47	8.11	-0.14	41.86
0.004	10.13	-0.14	45.47	8.12	-0.14	41.86
0.008	10.15	-0.14	45.47	8.14	-0.14	41.85
0.012	10.21	-0.14	45.45	8.19	-0.14	41.84
0.016	10.30	-0.14	45.44	8.29	-0.14	41.83
0.020	10.43	-0.14	45.43	8.41	-0.14	41.82
0.024	10.59	-0.14	45.41	8.56	-0.14	41.81
0.028	10.79	-0.14	45.40	8.75	-0.14	41.81
0.032	11.03	-0.14	45.39	8.99	-0.14	41.80
0.036	11.32	-0.14	45.38	9.26	-0.14	41.80
0.040	11.65	-0.14	45.37	9.58	-0.14	41.79
0.044	12.04	-0.14	45.35	9.94	-0.14	41.77
0.048	12.47	-0.14	45.32	10.36	-0.14	41.75
0.052	12.96	-0.14	45.29	10.82	-0.14	41.73
0.056	13.40	-0.14	45.22	11.22	-0.14	41.68
0.060	13.96	-0.14	45.16	11.74	-0.14	41.64
0.064	14.58	-0.14	45.09	12.30	-0.14	41.61
0.068	15.25	-0.14	45.02	12.91	-0.14	41.59
0.072	15.98	-0.14	44.95	13.56	-0.14	41.58
0.076	16.77	-0.14	44.88	14.25	-0.14	41.59
0.080	17.61	-0.14	44.82	15.00	-0.14	41.61
0.084	18.51	-0.14	44.76	15.79	-0.14	41.66
0.088	19.47	-0.14	44.71	16.63	-0.14	41.71
0.092	20.48	-0.14	44.66	17.52	-0.14	41.77
0.096	21.54	-0.14	44.60	18.46	-0.14	41.84
0.100	22.64	-0.14	44.54	19.44	-0.14	41.89
0.104	23.79	-0.14	44.45	20.45	-0.14	41.93
0.108	24.96	-0.14	44.33	21.52	-0.14	41.94
0.112	26.17	-0.14	44.17	22.51	-0.14	41.92
0.116	27.39	-0.14	43.96	23.73	-0.14	41.84
0.120	28.62	-0.14	43.69	24.65	-0.14	41.71
0.124	29.85	-0.14	43.35	25.98	-0.14	41.51
0.128	31.07	-0.14	42.93	27.11	-0.14	41.25
0.132	32.27	-0.14	42.43	28.22	-0.14	40.90
0.136	33.42	-0.14	41.84	29.30	-0.14	40.47
0.140	34.54	-0.14	41.17	30.34	-0.14	39.96
0.144	35.60	-0.14	40.41	31.35	-0.14	39.37
0.148	36.63	-0.14	39.56	32.30	-0.14	38.71
0.152	37.55	-0.14	38.63	33.20	-0.14	37.96
0.156	38.42	-0.14	37.62	34.05	-0.14	37.15
0.160	39.25	-0.14	36.50	34.85	-0.14	36.24
0.164	39.92	-0.14	35.38	35.51	-0.14	35.34
0.168	40.49	-0.14	34.17	36.09	-0.14	34.38
0.172	40.94	-0.14	32.92	36.57	-0.14	33.38
0.176	41.27	-0.14	31.65	36.96	-0.14	32.38
0.180	41.50	-0.14	30.36	37.28	-0.14	31.37

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	HEAD PITCH (DEG)	HEAD ROLL (DEG)	NECK PITCH (DEG)	NECK ROLL (DEG)
0.000	7.061	0.00	-4.44	0.00
0.004	7.055	0.00	-4.45	0.00
0.008	7.030	0.00	-4.47	0.00
0.012	7.006	0.00	-4.49	0.00
0.016	7.007	0.00	-4.48	0.00
0.020	7.051	0.00	-4.44	0.00
0.024	7.152	0.00	-4.34	0.00
0.028	7.311	0.00	-4.20	0.00
0.032	7.515	0.00	-4.01	0.00
0.036	7.745	0.00	-3.78	0.00
0.040	7.986	0.00	-3.51	0.00
0.044	8.235	0.00	-3.20	0.00
0.048	8.505	0.00	-2.83	0.00
0.052	8.826	0.00	-2.38	0.00
0.056	9.243	0.00	-1.82	0.00
0.060	9.804	0.00	-1.13	0.00
0.064	10.557	0.00	-0.26	0.00
0.068	11.543	0.00	0.81	0.00
0.072	12.785	0.00	2.09	0.00
0.076	14.295	0.00	3.59	0.00
0.080	16.070	0.00	5.32	0.00
0.084	18.081	0.00	7.25	0.00
0.088	20.288	0.00	9.37	0.00
0.092	22.642	0.00	11.64	0.00
0.096	25.094	0.00	14.02	0.00
0.100	27.605	0.00	16.51	0.00
0.104	30.145	0.00	19.06	0.00
0.108	32.697	0.00	21.67	0.00
0.112	35.251	0.00	24.31	0.00
0.116	37.800	0.00	26.99	0.00
0.120	40.337	0.00	29.68	0.00
0.124	42.860	0.00	32.38	0.00
0.128	45.368	0.00	35.07	0.00
0.132	47.847	0.00	37.75	0.00
0.136	50.310	0.00	40.41	0.00
0.140	52.759	0.00	43.05	0.00
0.144	55.210	0.00	45.67	0.00
0.148	57.677	0.00	48.29	0.00
0.152	60.163	0.00	50.91	0.00
0.156	62.697	0.00	53.59	0.00
0.160	65.336	0.00	56.40	0.00
0.164	68.250	0.00	59.36	0.00
0.168	71.394	0.00	62.47	0.00
0.172	74.758	0.00	65.66	0.00
0.176	78.281	0.00	68.89	0.00
0.180	81.890	0.00	72.13	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	RIGHT UPPER ARM X (IN)	RIGHT UPPER ARM Y (IN)	RIGHT UPPER ARM Z (IN)	RIGHT LOWER ARM X (IN)	RIGHT LOWER ARM Y (IN)	RIGHT LOWER ARM Z (IN)
0.000	10.67	-6.48	32.04	18.56	-6.48	24.20
0.004	10.68	-6.48	32.03	18.57	-6.48	24.20
0.008	10.71	-6.48	32.03	18.60	-6.48	24.19
0.012	10.76	-6.48	32.02	18.65	-6.48	24.18
0.016	10.85	-6.48	32.01	18.74	-6.48	24.17
0.020	10.97	-6.48	32.00	18.85	-6.48	24.16
0.024	11.11	-6.48	31.99	18.99	-6.48	24.14
0.028	11.29	-6.48	31.98	19.14	-6.48	24.11
0.032	11.48	-6.48	31.96	19.33	-6.48	24.08
0.036	11.72	-6.48	31.95	19.54	-6.48	24.05
0.040	11.99	-6.48	31.93	19.79	-6.48	24.00
0.044	12.31	-6.48	31.90	20.07	-6.48	23.94
0.048	12.65	-6.48	31.87	20.38	-6.48	23.88
0.052	13.03	-6.48	31.82	20.72	-6.48	23.80
0.056	13.34	-6.48	31.75	20.97	-6.48	23.69
0.060	13.75	-6.48	31.70	21.32	-6.48	23.58
0.064	14.18	-6.48	31.64	21.69	-6.48	23.47
0.068	14.63	-6.48	31.59	22.06	-6.48	23.35
0.072	15.10	-6.48	31.56	22.44	-6.48	23.24
0.076	15.59	-6.48	31.54	22.83	-6.48	23.13
0.080	16.11	-6.48	31.54	23.22	-6.48	23.02
0.084	16.64	-6.48	31.57	23.61	-6.48	22.93
0.088	17.20	-6.48	31.61	24.00	-6.48	22.84
0.092	17.78	-6.48	31.67	24.40	-6.48	22.76
0.096	18.39	-6.48	31.74	24.81	-6.48	22.69
0.100	19.02	-6.48	31.81	25.22	-6.48	22.62
0.104	19.68	-6.48	31.88	25.65	-6.48	22.54
0.108	20.37	-6.48	31.94	26.09	-6.48	22.47
0.112	21.08	-6.48	31.98	26.55	-6.48	22.38
0.116	21.82	-6.48	31.99	27.03	-6.48	22.28
0.120	22.56	-6.48	31.95	27.54	-6.48	22.15
0.124	23.33	-6.48	31.87	28.07	-6.48	22.00
0.128	24.09	-6.48	31.72	28.64	-6.48	21.81
0.132	24.86	-6.48	31.52	29.23	-6.48	21.58
0.136	25.63	-6.48	31.24	29.85	-6.48	21.30
0.140	26.38	-6.48	30.89	30.50	-6.48	20.98
0.144	27.12	-6.48	30.46	31.18	-6.48	20.60
0.148	27.84	-6.48	29.96	31.89	-6.48	20.17
0.152	28.53	-6.48	29.39	32.60	-6.48	19.69
0.156	29.20	-6.48	28.76	33.33	-6.48	19.17
0.160	29.85	-6.48	28.05	34.10	-6.48	18.58
0.164	30.38	-6.48	27.36	34.80	-6.48	18.03
0.168	30.88	-6.48	26.62	35.50	-6.48	17.44
0.172	31.30	-6.48	25.86	36.15	-6.48	16.83
0.176	31.67	-6.48	25.09	36.76	-6.48	16.22
0.180	31.98	-6.48	24.34	37.33	-6.48	15.63

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	RIGHT UPPER ARM PITCH (DEG)	RIGHT UPPER ARM ROLL (DEG)	RIGHT LOWER ARM PITCH (DEG)	RIGHT LOWER ARM ROLL (DEG)
0.000	-16.000	0.00	14.00	0.00
0.004	-16.004	0.00	14.00	0.00
0.008	-16.015	0.00	14.00	0.00
0.012	-16.021	0.00	14.00	0.00
0.016	-16.015	0.00	14.01	0.00
0.020	-15.986	0.00	14.04	0.00
0.024	-15.925	0.00	14.10	0.00
0.028	-15.830	0.00	14.20	0.00
0.032	-15.698	0.00	14.32	0.00
0.036	-15.533	0.00	14.49	0.00
0.040	-15.332	0.00	14.68	0.00
0.044	-15.093	0.00	14.89	0.00
0.048	-14.810	0.00	15.13	0.00
0.052	-14.482	0.00	15.38	0.00
0.056	-14.109	0.00	15.68	0.00
0.060	-13.6[illegible]	0.00	16.03	0.00
0.064	-13.217	0.00	16.45	0.00
0.068	-12.685	0.00	16.97	0.00
0.072	-12.072	0.00	17.58	0.00
0.076	-11.361	0.00	18.29	0.00
0.080	-10.544	0.00	19.10	0.00
0.084	-9.616	0.00	20.03	0.00
0.088	-8.571	0.00	21.07	0.00
0.092	-7.414	0.00	22.20	0.00
0.096	-6.146	0.00	23.42	0.00
0.100	-4.772	0.00	24.70	0.00
0.104	-3.306	0.00	26.00	0.00
0.108	-1.765	0.00	27.30	0.00
0.112	-0.173	0.00	28.57	0.00
0.116	1.446	0.00	29.77	0.00
0.120	3.063	0.00	30.88	0.00
0.124	4.645	0.00	31.86	0.00
0.128	6.160	0.00	32.66	0.00
0.132	7.570	0.00	33.25	0.00
0.136	8.843	0.00	33.60	0.00
0.140	9.943	0.00	33.69	0.00
0.144	10.839	0.00	33.51	0.00
0.148	11.501	0.00	33.05	0.00
0.152	11.902	0.00	32.32	0.00
0.156	12.009	0.00	31.31	0.00
0.160	11.783	0.00	30.06	0.00
0.164	11.203	0.00	28.60	0.00
0.168	10.274	0.00	26.99	0.00
0.172	9.037	0.00	25.27	0.00
0.176	7.551	0.00	23.47	0.00
0.180	5.900	0.00	21.66	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	LEFT UPPER ARM			LEFT LOWER ARM		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	10.67	6.20	32.04	18.56	6.20	24.20
0.004	10.68	6.20	32.03	18.57	6.20	24.20
0.008	10.71	6.20	32.03	18.60	6.20	24.19
0.012	10.76	6.20	32.02	18.65	6.20	24.18
0.016	10.85	6.20	32.01	18.74	6.20	24.17
0.020	10.97	6.20	32.00	18.85	6.20	24.16
0.024	11.11	6.20	31.99	18.99	6.20	24.14
0.028	11.28	6.20	31.98	19.14	6.20	24.11
0.032	11.48	6.20	31.96	19.33	6.20	24.08
0.036	11.72	6.20	31.95	19.54	6.20	24.05
0.040	11.99	6.20	31.93	19.79	6.20	24.00
0.044	12.31	6.20	31.90	20.07	6.20	23.94
0.048	12.65	6.20	31.87	20.38	6.20	23.88
0.052	13.03	6.20	31.82	20.72	6.20	23.80
0.056	13.39	6.20	31.75	20.97	6.20	23.69
0.060	13.75	6.20	31.70	21.32	6.20	23.58
0.064	14.18	6.20	31.64	21.69	6.20	23.47
0.068	14.63	6.20	31.59	22.06	6.20	23.35
0.072	15.10	6.20	31.56	22.44	6.20	23.24
0.076	15.59	6.20	31.54	22.83	6.20	23.13
0.080	16.11	6.20	31.54	23.22	6.20	23.02
0.084	16.64	6.20	31.57	23.61	6.20	22.93
0.088	17.20	6.20	31.61	24.00	6.20	22.84
0.092	17.78	6.20	31.67	24.40	6.20	22.76
0.096	18.39	6.20	31.74	24.81	6.20	22.69
0.100	19.02	6.20	31.81	25.22	6.20	22.62
0.104	19.68	6.20	31.88	25.65	6.20	22.54
0.108	20.37	6.20	31.94	26.09	6.20	22.47
0.112	21.08	6.20	31.98	26.55	6.20	22.38
0.116	21.82	6.20	31.99	27.03	6.20	22.28
0.120	22.56	6.20	31.95	27.54	6.20	22.15
0.124	23.33	6.20	31.87	28.07	6.20	22.00
0.128	24.09	6.20	31.72	28.64	6.20	21.81
0.132	24.86	6.20	31.52	29.23	6.20	21.58
0.136	25.63	6.20	31.24	29.85	6.20	21.30
0.140	26.38	6.20	30.89	30.50	6.20	20.98
0.144	27.12	6.20	30.46	31.18	6.20	20.60
0.148	27.84	6.20	29.96	31.88	6.20	20.17
0.152	28.53	6.20	29.39	32.60	6.20	19.69
0.156	29.20	6.20	28.76	33.33	6.20	19.17
0.160	29.85	6.20	28.05	34.10	6.20	18.58
0.164	30.38	6.20	27.36	34.80	6.20	18.03
0.168	30.88	6.20	26.62	35.50	6.20	17.44
0.172	31.30	6.20	25.86	36.15	6.20	16.83
0.176	31.67	6.20	25.09	36.76	6.20	16.22
0.180	31.98	6.20	24.34	37.33	6.20	15.63

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	LEFT UPPER ARM		LEFT LOWER ARM	
(SEC)	PITCH (DEG) --	ROLL (DEG)	PITCH (DEG) --	ROLL (DEG)
0.000	-16.000	0.00	14.00	0.00
0.004	-16.004	0.00	14.00	0.00
0.008	-16.015	0.00	14.00	0.00
0.012	-16.021	0.00	14.00	0.00
0.016	-16.015	0.00	14.01	0.00
0.020	-15.986	0.00	14.04	0.00
0.024	-15.925	0.00	14.10	0.00
0.028	-15.830	0.00	14.20	0.00
0.032	-15.698	0.00	14.32	0.00
0.036	-15.533	0.00	14.49	0.00
0.040	-15.333	0.00	14.68	0.00
0.044	-15.093	0.00	14.89	0.00
0.048	-14.810	0.00	15.13	0.00
0.052	-14.482	0.00	15.38	0.00
0.056	-14.109	0.00	15.68	0.00
0.060	-13.689	0.00	16.03	0.00
0.064	-13.217	0.00	16.45	0.00
0.068	-12.685	0.00	16.97	0.00
0.072	-12.072	0.00	17.58	0.00
0.076	-11.361	0.00	18.29	0.00
0.080	-10.544	0.00	19.10	0.00
0.084	-9.616	0.00	20.03	0.00
0.088	-8.571	0.00	21.07	0.00
0.092	-7.414	0.00	22.20	0.00
0.096	-6.146	0.00	23.42	0.00
0.100	-4.772	0.00	24.70	0.00
0.104	-3.306	0.00	26.00	0.00
0.108	-1.765	0.00	27.30	0.00
0.112	-0.173	0.00	28.57	0.00
0.116	1.446	0.00	29.77	0.00
0.120	3.063	0.00	30.88	0.00
0.124	4.645	0.00	31.86	0.00
0.128	6.160	0.00	32.66	0.00
0.132	7.570	0.00	33.25	0.00
0.136	8.843	0.00	33.60	0.00
0.140	9.943	0.00	33.69	0.00
0.144	10.839	0.00	33.51	0.00
0.148	11.501	0.00	33.05	0.00
0.152	11.902	0.00	32.32	0.00
0.156	12.009	0.00	31.31	0.00
0.160	11.783	0.00	30.06	0.00
0.164	11.203	0.00	28.60	0.00
0.168	10.274	0.00	26.99	0.00
0.172	9.037	0.00	25.27	0.00
0.176	7.551	0.00	23.47	0.00
0.180	5.900	0.00	21.66	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME	RIGHT THIGH			RIGHT LOWER LEG		
(SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)
0.000	22.95	-3.84	18.92	31.64	-3.84	8.59
0.004	22.95	-3.84	18.92	31.64	-3.84	8.59
0.008	22.97	-3.84	18.92	31.65	-3.84	8.58
0.012	23.01	-3.84	18.92	31.69	-3.84	8.58
0.016	23.08	-3.84	18.92	31.75	-3.84	8.58
0.020	23.19	-3.84	18.92	31.85	-3.84	8.57
0.024	23.32	-3.84	18.92	31.99	-3.84	8.57
0.028	23.47	-3.84	18.90	32.15	-3.84	8.57
0.032	23.63	-3.84	18.88	32.33	-3.84	8.57
0.036	23.80	-3.84	18.85	32.54	-3.84	8.57
0.040	23.97	-3.84	18.81	32.77	-3.84	8.57
0.044	24.13	-3.84	18.76	33.01	-3.84	8.57
0.048	24.27	-3.84	18.71	33.26	-3.84	8.56
0.052	24.40	-3.84	18.65	33.52	-3.84	8.54
0.056	24.50	-3.84	18.59	33.78	-3.84	8.53
0.060	24.58	-3.84	18.54	34.05	-3.84	8.52
0.064	24.63	-3.84	18.48	34.32	-3.84	8.51
0.068	24.65	-3.84	18.42	34.59	-3.84	8.49
0.072	24.66	-3.84	18.36	34.87	-3.84	8.46
0.076	24.64	-3.84	18.29	35.15	-3.84	8.42
0.080	24.60	-3.84	18.23	35.43	-3.84	8.38
0.084	24.55	-3.84	18.16	35.71	-3.84	8.33
0.088	24.50	-3.84	18.10	35.99	-3.84	8.27
0.092	24.43	-3.84	18.04	36.26	-3.84	8.21
0.096	24.37	-3.84	17.98	36.52	-3.84	8.15
0.100	24.31	-3.84	17.94	36.78	-3.84	8.09
0.104	24.24	-3.84	17.91	37.02	-3.84	8.03
0.108	24.19	-3.84	17.88	37.25	-3.84	7.98
0.112	24.14	-3.84	17.86	37.48	-3.84	7.93
0.116	24.09	-3.84	17.85	37.69	-3.84	7.89
0.120	24.06	-3.84	17.85	37.90	-3.84	7.86
0.124	24.03	-3.84	17.85	38.10	-3.84	7.84
0.128	24.02	-3.84	17.85	38.30	-3.84	7.84
0.132	24.01	-3.84	17.85	38.50	-3.84	7.85
0.136	24.02	-3.84	17.85	38.70	-3.84	7.87
0.140	24.03	-3.84	17.84	38.91	-3.84	7.91
0.144	24.05	-3.84	17.83	39.12	-3.84	7.98
0.148	24.08	-3.84	17.80	39.35	-3.84	8.07
0.152	24.11	-3.84	17.76	39.60	-3.84	8.19
0.156	24.17	-3.84	17.70	39.87	-3.84	8.31
0.160	24.24	-3.84	17.60	40.16	-3.84	8.44
0.164	24.31	-3.84	17.46	40.46	-3.84	8.55
0.168	24.36	-3.84	17.30	40.73	-3.84	8.64
0.172	24.39	-3.84	17.11	40.98	-3.84	8.71
0.176	24.39	-3.84	16.93	41.17	-3.84	8.76
0.180	24.37	-3.84	16.76	41.31	-3.84	8.78

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	RIGHT THIGH PITCH (DEG)	RIGHT THIGH ROLL (DEG)	RIGHT LOWER LEG PITCH (DEG)	RIGHT LOWER LEG ROLL (DEG)
0.000	-3.873	0.00	-3.77	0.00
0.004	-3.855	0.00	-3.76	0.00
0.008	-3.816	0.00	-3.73	0.00
0.012	-3.773	0.00	-3.69	0.00
0.016	-3.737	0.00	-3.65	0.00
0.020	-3.718	0.00	-3.62	0.00
0.024	-3.721	0.00	-3.62	0.00
0.028	-3.771	0.00	-3.66	0.00
0.032	-3.885	0.00	-3.7[illegible]	0.00
0.036	-4.068	0.00	-3.95	0.00
0.040	-4.300	0.00	-4.24	0.00
0.044	-4.542	0.00	-4.64	0.00
0.048	-4.773	0.00	-5.19	0.00
0.052	-4.988	0.00	5.39	0.00
0.056	-5.189	0.00	-6.74	0.00
0.060	-5.363	0.00	-7.74	0.00
0.064	-5.477	0.00	-8.92	0.00
0.068	-5.489	0.00	-10.27	0.00
0.072	-5.382	0.00	-11.78	0.00
0.076	-5.163	0.00	-13.42	0.00
0.080	-4.834	0.00	-15.16	0.00
0.084	-4.394	0.00	-16.96	0.00
0.088	-3.837	0.00	-18.85	0.00
0.092	-3.162	0.00	-20.73	0.00
0.096	-2.367	0.00	-22.60	0.00
0.100	-1.462	0.00	-24.44	0.00
0.104	-0.463	0.00	-26.24	0.00
0.108	0.608	0.00	-27.97	0.00
0.112	1.725	0.00	-29.64	0.00
0.116	2.860	0.00	-31.25	0.00
0.120	3.984	0.00	-32.79	0.00
0.124	5.073	0.00	-34.28	0.00
0.128	6.101	0.00	-35.73	0.00
0.132	7.058	0.00	-37.14	0.00
0.136	7.937	0.00	-38.52	0.00
0.140	8.721	0.00	-39.89	0.00
0.144	9.381	0.00	-41.27	0.00
0.148	9.881	0.00	-42.67	0.00
0.152	10.199	0.00	-44.11	0.00
0.156	10.358	0.00	-45.62	0.00
0.160	10.401	0.00	-47.20	0.00
0.164	10.367	0.00	-48.86	0.00
0.168	10.292	0.00	-50.60	0.00
0.172	10.208	0.00	-52.41	0.00
0.176	10.145	0.00	-54.22	0.00
0.180	10.227	0.00	-55.94	0.00

OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	LEFT THIGH X (IN)	LEFT THIGH Y (IN)	LEFT THIGH Z (IN)	LEFT LOWER LEG X (IN)	LEFT LOWER LEG Y (IN)	LEFT LOWER LEG Z (IN)
0.000	22.95	3.56	18.92	31.64	3.56	8.59
0.004	22.95	3.56	18.92	31.64	3.55	8.59
0.008	22.97	3.56	18.92	31.65	3.56	8.58
0.012	23.01	3.56	18.92	31.69	3.56	8.58
0.016	23.08	3.56	18.92	31.75	3.56	8.58
0.020	23.19	3.56	18.92	31.85	3.56	8.57
0.024	23.32	3.56	18.92	31.99	3.56	8.57
0.028	23.47	3.56	18.90	32.15	3.56	8.57
0.032	23.63	3.56	18.88	32.33	3.56	8.57
0.036	23.80	3.56	18.85	32.54	3.56	8.57
0.040	23.97	3.56	18.81	32.77	3.56	8.57
0.044	24.13	3.56	18.76	33.01	3.56	8.57
0.048	24.27	3.56	18.71	33.26	3.56	8.56
0.052	24.40	3.56	18.65	33.52	3.55	8.54
0.056	24.50	3.56	18.59	33.78	3.56	8.53
0.060	24.58	3.56	18.54	34.05	3.56	8.52
0.064	24.63	3.56	18.48	34.32	3.56	8.51
0.068	24.65	3.56	18.42	34.59	3.56	8.49
0.072	24.66	3.56	18.36	34.87	3.56	8.46
0.076	24.64	3.56	18.29	35.15	3.56	8.42
0.080	24.60	3.56	18.23	35.43	3.56	8.38
0.084	24.55	3.56	18.16	35.71	3.56	8.33
0.088	24.50	3.56	18.10	35.99	3.56	8.27
0.092	24.43	3.56	18.04	36.26	3.56	8.21
0.096	24.37	3.56	17.98	36.52	3.56	8.15
0.100	24.31	3.56	17.94	36.78	3.56	8.09
0.104	24.24	3.56	17.91	37.02	3.56	8.03
0.108	24.19	3.56	17.88	37.25	3.56	7.98
0.112	24.14	3.56	17.86	37.48	3.56	7.93
0.116	24.09	3.56	17.85	37.69	3.56	7.89
0.120	24.06	3.56	17.85	37.90	3.56	7.86
0.124	24.03	3.56	17.85	38.10	3.56	7.84
0.128	24.02	3.56	17.85	38.30	3.56	7.84
0.132	24.01	3.56	17.85	38.50	3.56	7.85
0.136	24.02	3.56	17.85	38.70	3.56	7.87
0.140	24.03	3.56	17.84	38.91	3.56	7.91
0.144	24.05	3.56	17.83	39.12	3.56	7.98
0.148	24.08	3.56	17.80	39.35	3.56	8.07
0.152	24.11	3.56	17.76	39.60	3.56	8.19
0.156	24.17	3.56	17.70	39.87	3.55	8.31
0.160	24.24	3.56	17.60	40.16	3.56	8.44
0.164	24.31	3.56	17.46	40.46	3.56	8.55
0.168	24.36	3.56	17.30	40.73	3.56	8.64
0.172	24.39	3.56	17.11	40.98	3.56	8.71
0.176	24.39	3.56	16.93	41.17	3.56	8.76
0.180	24.37	3.56	16.76	41.31	3.56	8.78

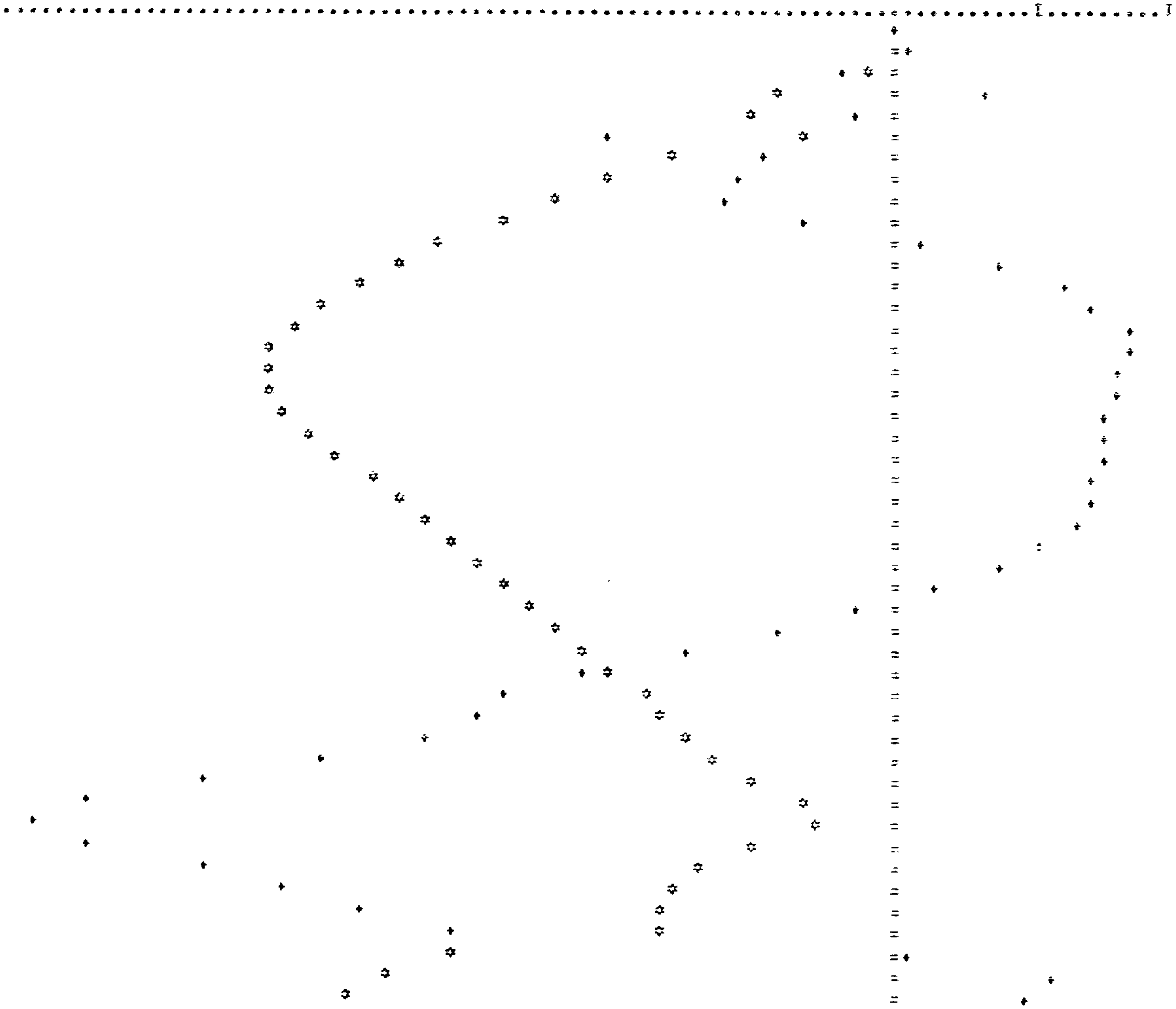
OCCUPANT SEGMENT POSITION
(IN AIRCRAFT REFERENCE FRAME)

TIME (SEC)	LEFT THIGH PITCH (DEG)	-- ROLL (DEG)	LEFT LOWER LEG PITCH (DEG)	-- ROLL (DEG)
0.000	-3.873	0.00	-3.77	0.00
0.004	-3.855	0.00	-3.76	0.00
0.008	-3.816	0.00	-3.73	0.00
0.012	-3.773	0.00	-3.69	0.00
0.016	-3.737	0.00	-3.65	0.00
0.020	-3.718	0.00	-3.62	0.00
0.024	-3.721	0.00	-3.62	0.00
0.028	-3.771	0.00	-3.66	0.00
0.032	-3.885	0.00	-3.76	0.00
0.036	-4.068	0.00	-3.95	0.00
0.040	-4.300	0.00	-4.24	0.00
0.044	-4.542	0.00	-4.64	0.00
0.048	-4.773	0.00	-5.19	0.00
0.052	-4.988	0.00	-5.89	0.00
0.056	-5.189	0.00	-6.74	0.00
0.060	-5.363	0.00	-7.74	0.00
0.064	-5.477	0.00	-8.92	0.00
0.068	-5.489	0.00	-10.27	0.00
0.072	-5.382	0.00	-11.78	0.00
0.076	-5.163	0.00	-13.42	0.00
0.080	-4.834	0.00	-15.16	0.00
0.084	-4.394	0.00	-16.98	0.00
0.088	-3.837	0.00	-18.85	0.00
0.092	-3.162	0.00	-20.73	0.00
0.096	-2.367	0.00	-22.60	0.00
0.100	-1.462	0.00	-24.44	0.00
0.104	-0.463	0.00	-26.24	0.00
0.108	0.608	0.00	-27.97	0.00
0.112	1.725	0.00	-29.64	0.00
0.116	2.860	0.00	-31.25	0.00
0.120	3.984	0.00	-32.79	0.00
0.124	5.073	0.00	-34.28	0.00
0.128	6.101	0.00	-35.73	0.00
0.132	[illegible]	0.00	-37.14	0.00
0.136	7.937	0.00	-38.52	0.00
0.140	8.721	0.00	-39.89	0.00
0.144	9.381	0.00	-41.27	0.00
0.148	9.881	0.00	-42.67	0.00
0.152	10.199	0.00	-44.11	0.00
0.156	10.358	0.00	-45.62	0.00
0.160	10.401	0.00	-47.20	0.00
0.164	10.367	0.00	-48.86	0.00
0.168	10.292	0.00	-50.60	0.00
0.172	10.204	0.00	-52.41	0.00
0.176	10.145	0.00	-54.22	0.00
0.180	10.227	0.00	-55.94	0.00

OCCUPANT SEGMENT ACCELERATION
(IN ACCELEROMETER DIRECTIONS)

TIME (SEC)	PELVIS X (G) *	PELVIS Y (G) =	PELVIS Z (G) +
0.000	0.00	0.00	0.00
0.004	0.02	0.00	0.27
0.008	-0.20	0.00	-0.56
0.012	-1.43	0.00	1.19
0.016	-1.68	0.00	-0.41
0.020	-1.09	0.00	-3.45
0.024	-2.65	0.00	-1.58
0.028	-3.40	0.00	-1.81
0.032	-4.08	0.00	-2.02
0.036	-4.80	0.00	-1.00
0.040	-5.46	0.00	0.30
0.044	-6.05	0.00	1.37
0.048	-6.56	0.00	2.09
0.052	-6.99	0.00	2.52
0.056	-7.38	0.00	2.87
0.060	-7.59	0.00	2.93
0.064	-7.67	0.00	2.79
0.068	-7.63	0.00	2.78
0.072	-7.43	0.00	2.66
0.076	-7.12	0.00	2.59
0.080	-6.77	0.00	2.59
0.084	-6.42	0.00	2.52
0.088	-6.07	0.00	2.43
0.092	-5.73	0.00	2.25
0.096	-5.39	0.00	1.89
0.100	-5.06	0.00	1.32
0.104	-4.74	0.00	0.53
0.108	-4.43	0.00	-0.39
0.112	-4.10	0.00	-1.41
0.116	-3.76	0.00	-2.52
0.120	-3.40	0.00	-3.71
0.124	-2.99	0.00	-4.78
0.128	-2.82	0.00	-5.05
0.132	-2.57	0.00	-5.76
0.136	-2.19	0.00	-6.96
0.140	-1.68	0.00	-8.43
0.144	-1.06	0.00	-9.83
0.148	-0.89	0.00	-10.50
0.152	-1.65	0.00	-9.78
0.156	-2.39	0.00	-8.50
0.160	-2.68	0.00	-7.47
0.164	-2.89	0.00	-6.43
0.168	-2.84	0.00	-5.46
0.172	-5.35	0.00	0.29
0.176	-6.13	0.00	1.96
0.180	-6.73	0.00	1.65

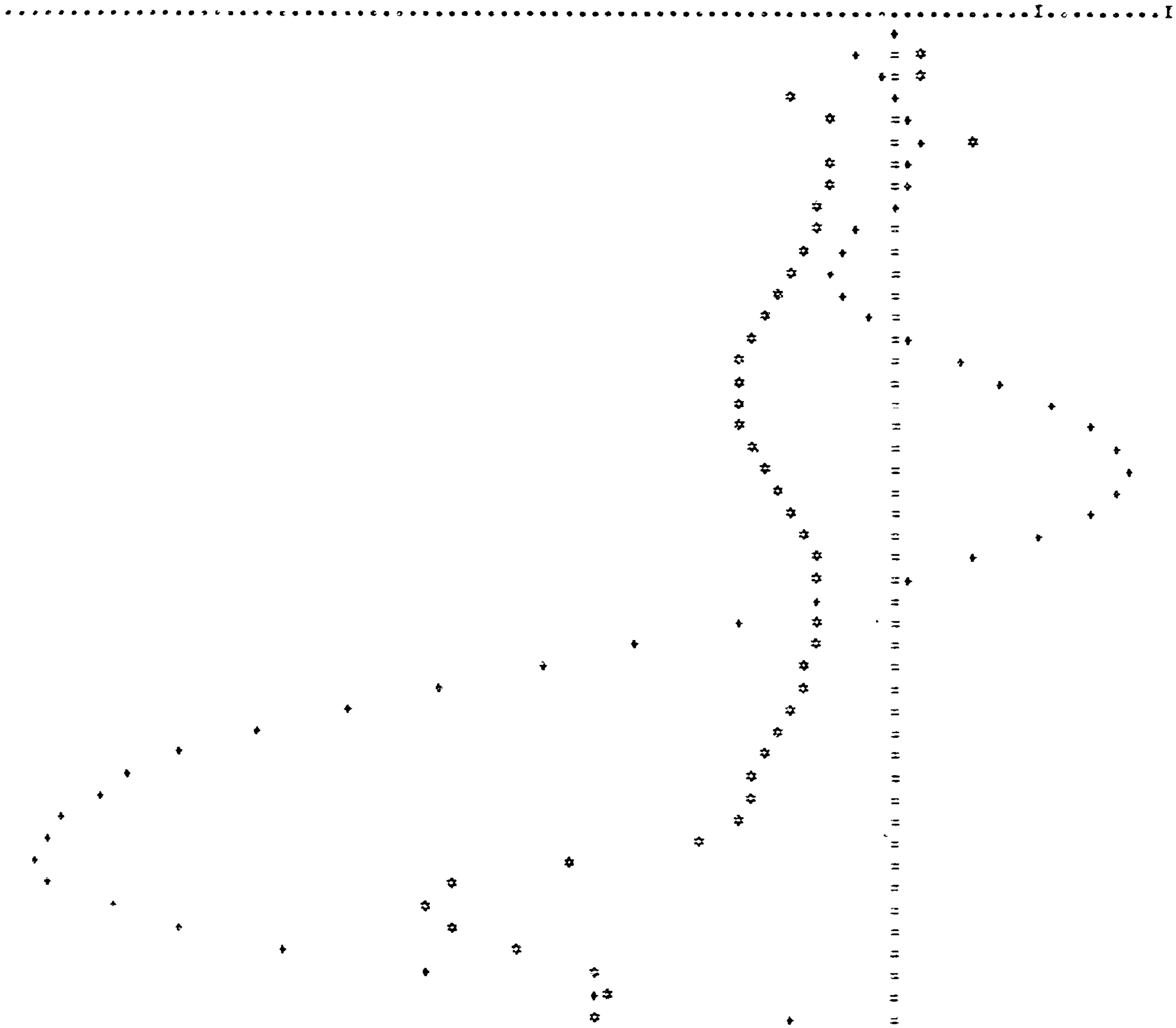
SCALE FACTOR = 0.160E+01



OCCUPANT SEGMENT ACCELERATION
(IN ACCELEROMETER DIRECTIONS)

CHEST

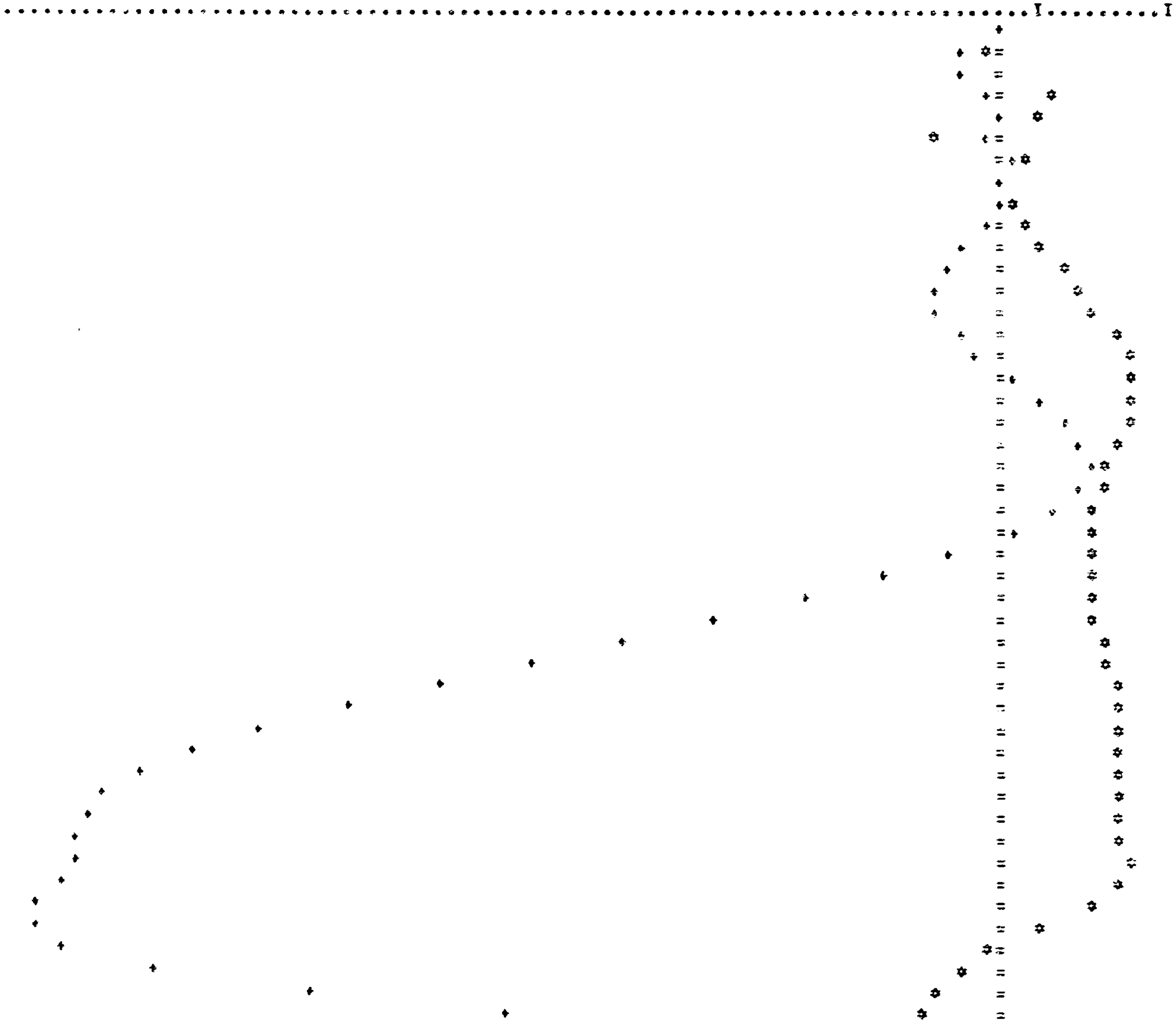
TIME (SEC)	X (G) ✡	Y (G) =	Z (G) +
0.000	0.00	0.00	0.00
0.004	0.36	0.00	-0.82
0.008	0.30	0.00	-0.29
0.012	-2.07	0.00	-0.02
0.016	-1.33	0.00	0.23
0.020	1.26	0.00	0.51
0.024	-1.31	0.00	0.26
0.028	-1.35	0.00	0.19
0.032	-1.50	0.00	-0.14
0.036	-1.60	0.00	-0.67
0.040	-1.74	0.00	-1.07
0.044	-1.91	0.00	-1.21
0.048	-2.13	0.00	-1.02
0.052	-2.38	0.00	-0.50
0.056	-2.67	0.00	0.12
0.060	-2.83	0.00	1.02
0.064	-2.92	0.00	1.98
0.068	-2.93	0.00	2.88
0.072	-2.88	0.00	3.63
0.076	-2.72	0.00	4.11
0.080	-2.47	0.00	4.26
0.084	-2.19	0.00	4.04
0.088	-1.92	0.00	3.46
0.092	-1.67	0.00	2.55
0.096	-1.51	0.00	1.41
0.100	-1.42	0.00	0.08
0.104	-1.40	0.00	-1.40
0.108	-1.45	0.00	-3.04
0.112	-1.54	0.00	-4.79
0.116	-1.68	0.00	-6.61
0.120	-1.85	0.00	-8.44
0.124	-2.04	0.00	-10.23
0.128	-2.17	0.00	-11.64
0.132	-2.36	0.00	-13.13
0.136	-2.58	0.00	-14.10
0.140	-2.77	0.00	-14.80
0.144	-2.87	0.00	-15.33
0.148	-3.63	0.00	-15.73
0.152	-5.99	0.00	-15.89
0.156	-8.12	0.00	-15.58
0.160	-8.81	0.00	-14.56
0.164	-8.21	0.00	-13.23
0.168	-7.02	0.00	-11.32
0.172	-5.60	0.00	-8.81
0.176	-5.38	0.00	-5.56
0.180	-5.62	0.00	-2.05



OCCUPANT SEGMENT ACCELERATION
(IN ACCELEROMETER DIRECTIONS)

TIME (SEC)	HEAD X (G) *	HEAD Y (G) =	HEAD Z (G) +
0.000	0.00	0.00	0.00
0.004	-0.32	0.00	-0.95
0.008	-0.70	0.00	-0.73
0.012	1.13	0.00	-0.10
0.016	1.00	0.00	0.12
0.020	-1.30	0.00	-0.09
0.024	0.52	0.00	0.38
0.028	0.15	0.00	0.20
0.032	0.35	0.00	-0.01
0.036	0.67	0.00	-0.34
0.040	1.06	0.00	-0.75
0.044	1.48	0.00	-1.14
0.048	1.89	0.00	-1.37
0.052	2.28	0.00	-1.33
0.056	2.66	0.00	-0.97
0.060	2.92	0.00	-0.46
0.064	3.05	0.00	0.22
0.068	3.06	0.00	0.95
0.072	2.97	0.00	1.59
0.076	2.80	0.00	2.01
0.080	2.58	0.00	2.12
0.084	2.36	0.00	1.86
0.088	2.19	0.00	1.24
0.092	2.09	0.00	0.24
0.096	2.06	0.00	-1.08
0.100	2.08	0.00	-2.67
0.104	2.17	0.00	-4.49
0.108	2.29	0.00	-6.47
0.112	2.44	0.00	-8.56
0.116	2.59	0.00	-10.71
0.120	2.72	0.00	-12.87
0.124	2.81	0.00	-14.95
0.128	2.85	0.00	-16.88
0.132	2.89	0.00	-18.49
0.136	2.89	0.00	-19.69
0.140	2.80	0.00	-20.51
0.144	2.62	0.00	-21.03
0.148	2.63	0.00	-21.24
0.152	2.96	0.00	-21.19
0.156	2.88	0.00	-21.42
0.160	2.11	0.00	-22.10
0.164	1.00	0.00	-22.02
0.168	-0.16	0.00	-21.88
0.172	-0.98	0.00	-19.44
0.176	-1.30	0.00	-15.69
0.180	-1.75	0.00	-11.20

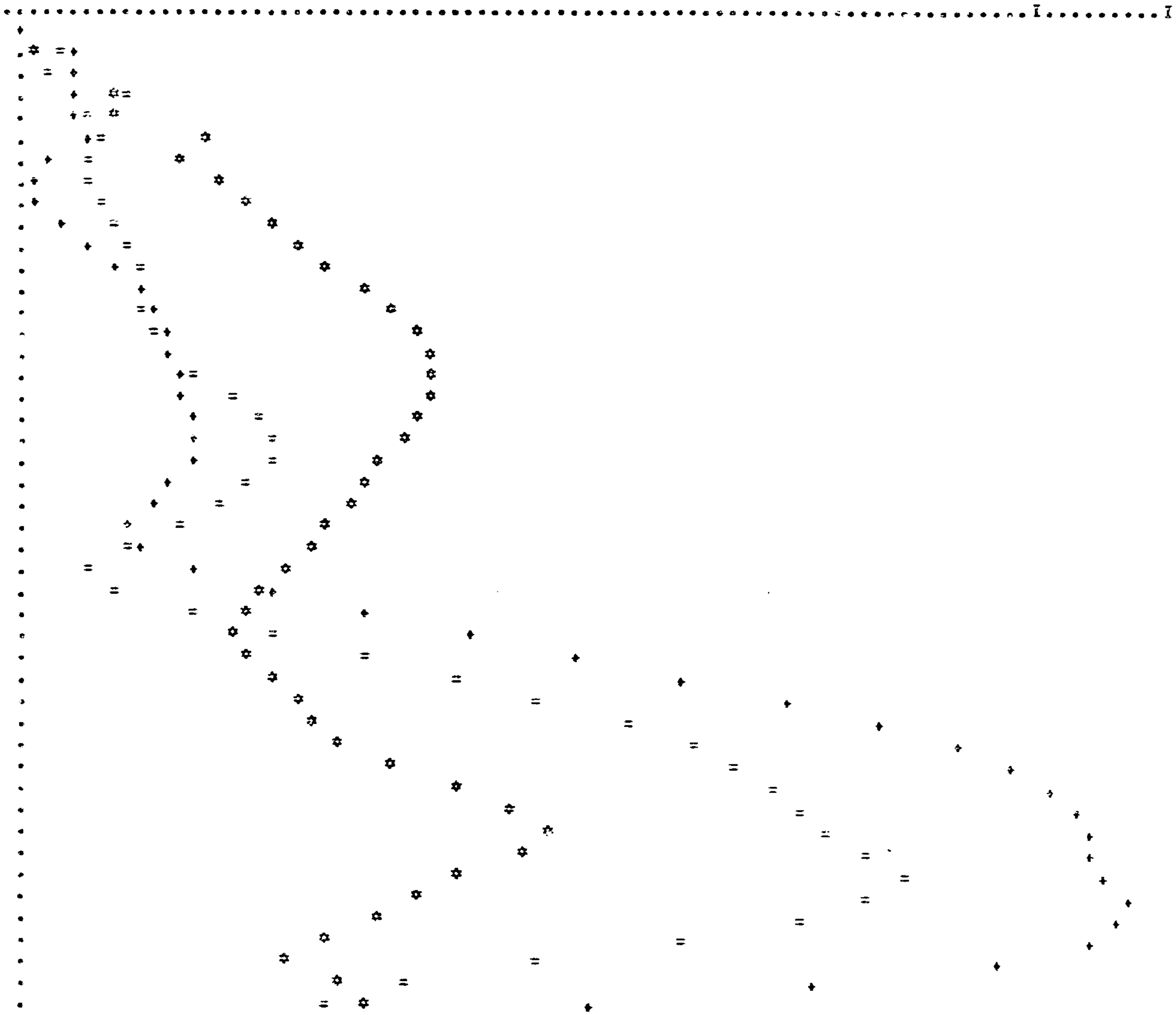
SCALE FACTOR = 0.299E+01



OCCUPANT SEGMENT ACCELERATION
(RESULTANTS)

TIME (SEC)	PELVIS (G) *	CHEST (G) =	HEAD (G) +
0.000	0.00	0.00	0.00
0.004	0.27	0.89	1.00
0.008	0.60	0.42	1.01
0.012	1.86	2.07	1.13
0.016	1.73	1.35	1.01
0.020	3.62	1.46	1.30
0.024	3.08	1.34	0.64
0.028	3.85	1.37	0.25
0.032	4.56	1.51	0.35
0.036	4.91	1.74	0.75
0.040	5.47	2.04	1.30
0.044	6.20	2.26	1.87
0.048	6.89	2.36	2.34
0.052	7.43	2.43	2.64
0.056	7.92	2.67	2.83
0.060	8.14	3.00	2.95
0.064	8.17	3.52	3.06
0.068	8.13	4.11	3.20
0.072	7.89	4.63	3.36
0.076	7.58	4.93	3.44
0.080	7.25	4.92	3.33
0.084	6.90	4.59	3.01
0.088	6.54	3.95	2.52
0.092	6.15	3.05	2.11
0.096	5.71	2.07	2.32
0.100	5.23	1.42	3.39
0.104	4.77	1.98	4.99
0.108	4.45	3.36	6.86
0.112	4.34	5.03	8.90
0.116	4.53	6.82	11.02
0.120	5.04	8.64	13.15
0.124	5.64	10.43	15.21
0.128	5.78	12.03	17.12
0.132	6.31	13.35	18.71
0.136	7.30	14.34	19.90
0.140	8.60	15.06	20.70
0.144	9.89	15.60	21.19
0.148	10.53	16.14	21.40
0.152	9.93	16.98	21.40
0.156	8.83	17.57	21.61
0.160	7.94	17.01	22.20
0.164	7.05	15.57	22.04
0.168	6.15	13.32	21.48
0.172	5.36	10.44	19.47
0.176	6.43	7.73	15.74
0.180	6.93	5.98	11.34

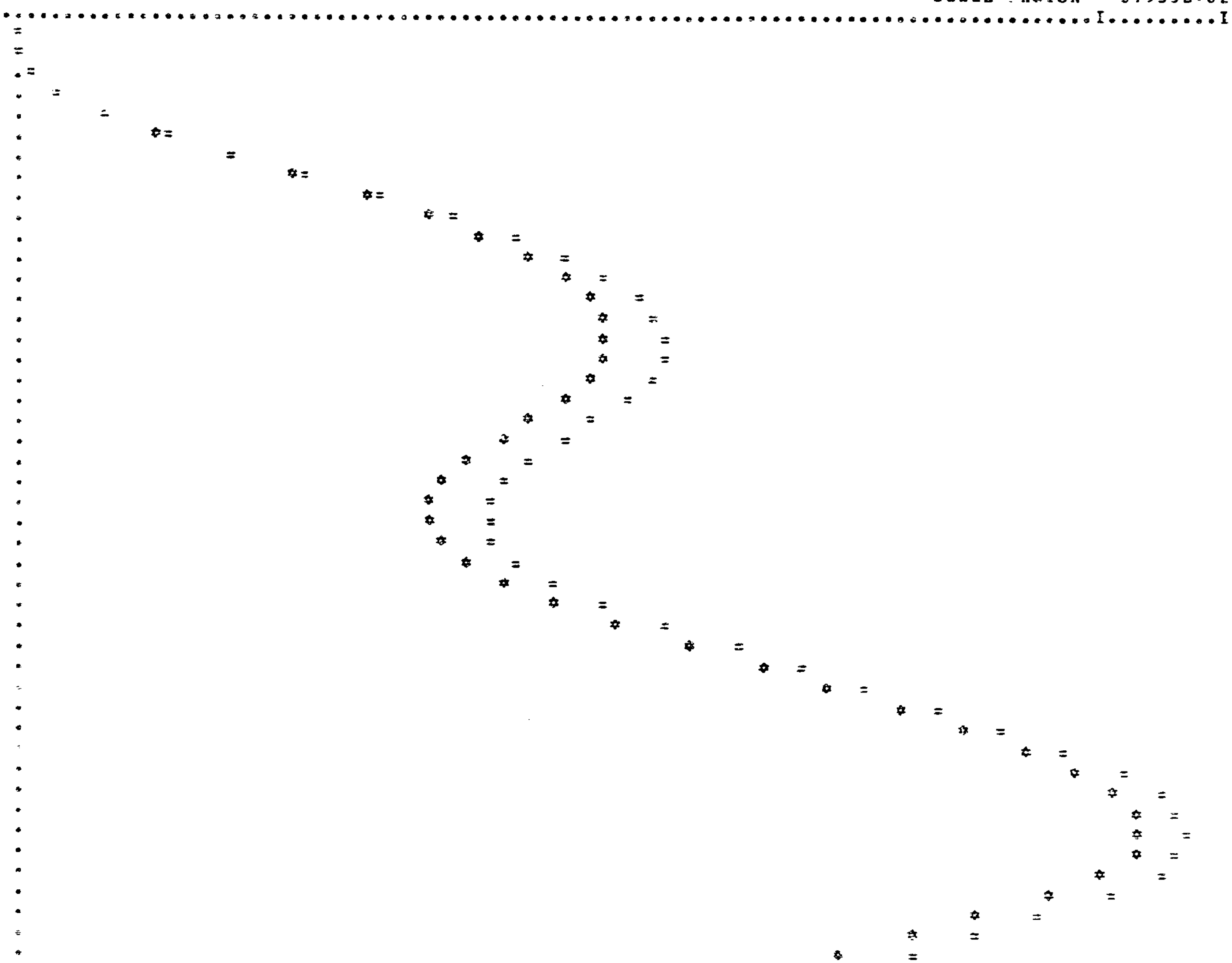
SCALE FACTOR = 0.264E+01



RESTRAINT SYSTEM LOADS

SCALE FACTOR = 0.950E+02

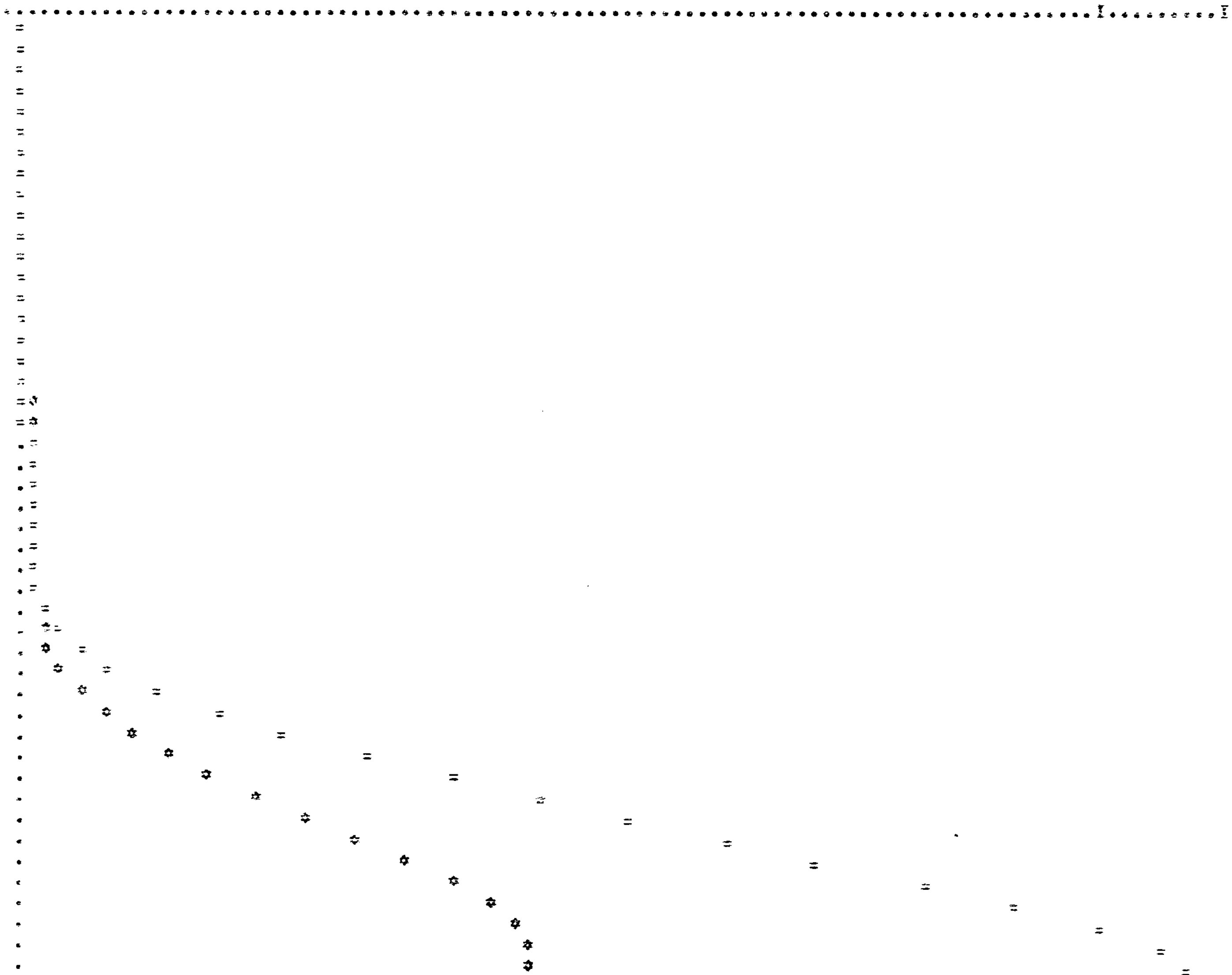
TIME (SEC)	RIGHT LAP (LB) *	LEFT LAP (LB) =
0.000	0.00	0.00
0.004	2.78	1.63
0.008	11.55	11.06
0.012	32.30	32.66
0.016	65.54	66.90
0.020	108.57	112.41
0.024	158.06	165.33
0.028	210.80	222.14
0.032	262.37	278.07
0.036	309.56	329.82
0.040	351.30	375.74
0.044	385.69	415.12
0.048	415.10	447.28
0.052	435.58	471.65
0.056	447.43	487.50
0.060	450.95	494.12
0.064	446.06	491.73
0.068	433.50	480.59
0.072	414.53	462.34
0.076	391.36	439.56
0.080	366.83	415.09
0.084	343.96	392.00
0.088	325.55	373.06
0.092	314.97	360.07
0.096	312.89	356.55
0.100	322.12	362.66
0.104	341.32	380.78
0.108	371.37	409.68
0.112	411.24	448.41
0.116	459.32	495.55
0.120	513.44	549.11
0.124	568.42	599.18
0.128	620.34	650.63
0.132	672.82	702.80
0.136	724.18	754.18
0.140	772.83	800.65
0.144	812.10	840.94
0.148	839.93	870.37
0.152	855.21	887.12
0.156	856.77	892.95
0.160	851.89	887.60
0.164	826.81	871.51
0.168	787.42	834.44
0.172	734.96	782.18
0.176	679.61	731.46
0.180	629.06	685.30



SEVERITY INDEX

SCALE FACTOR = 0.578E+01

TIME	CHEST (*)	HEAD (=)
0.000	0.00	0.00
0.004	0.01	0.00
0.008	0.02	0.01
0.012	0.03	0.01
0.016	0.05	0.01
0.020	0.06	0.01
0.024	0.06	0.01
0.028	0.07	0.01
0.032	0.07	0.01
0.036	0.08	0.01
0.040	0.09	0.01
0.044	0.10	0.02
0.048	0.12	0.03
0.052	0.14	0.05
0.056	0.16	0.08
0.060	0.19	0.11
0.064	0.22	0.14
0.068	0.28	0.17
0.072	0.36	0.21
0.076	0.46	0.26
0.080	0.57	0.30
0.084	0.67	0.33
0.088	0.75	0.36
0.092	0.79	0.38
0.096	0.82	0.39
0.100	0.82	0.42
0.104	0.83	0.49
0.108	0.85	0.66
0.112	0.93	1.01
0.116	1.10	1.69
0.120	1.44	2.66
0.124	2.00	4.19
0.128	2.85	6.30
0.132	4.01	9.03
0.136	5.44	12.32
0.140	7.10	16.05
0.144	8.94	20.08
0.148	10.38	24.28
0.152	13.17	28.51
0.156	15.67	32.79
0.160	18.19	37.26
0.164	20.36	41.98
0.168	21.95	46.45
0.172	22.93	50.32
0.176	23.43	52.97
0.180	23.67	54.35



DYNAMIC RESPONSE INDEX AND HEAD INJURY CRITERION

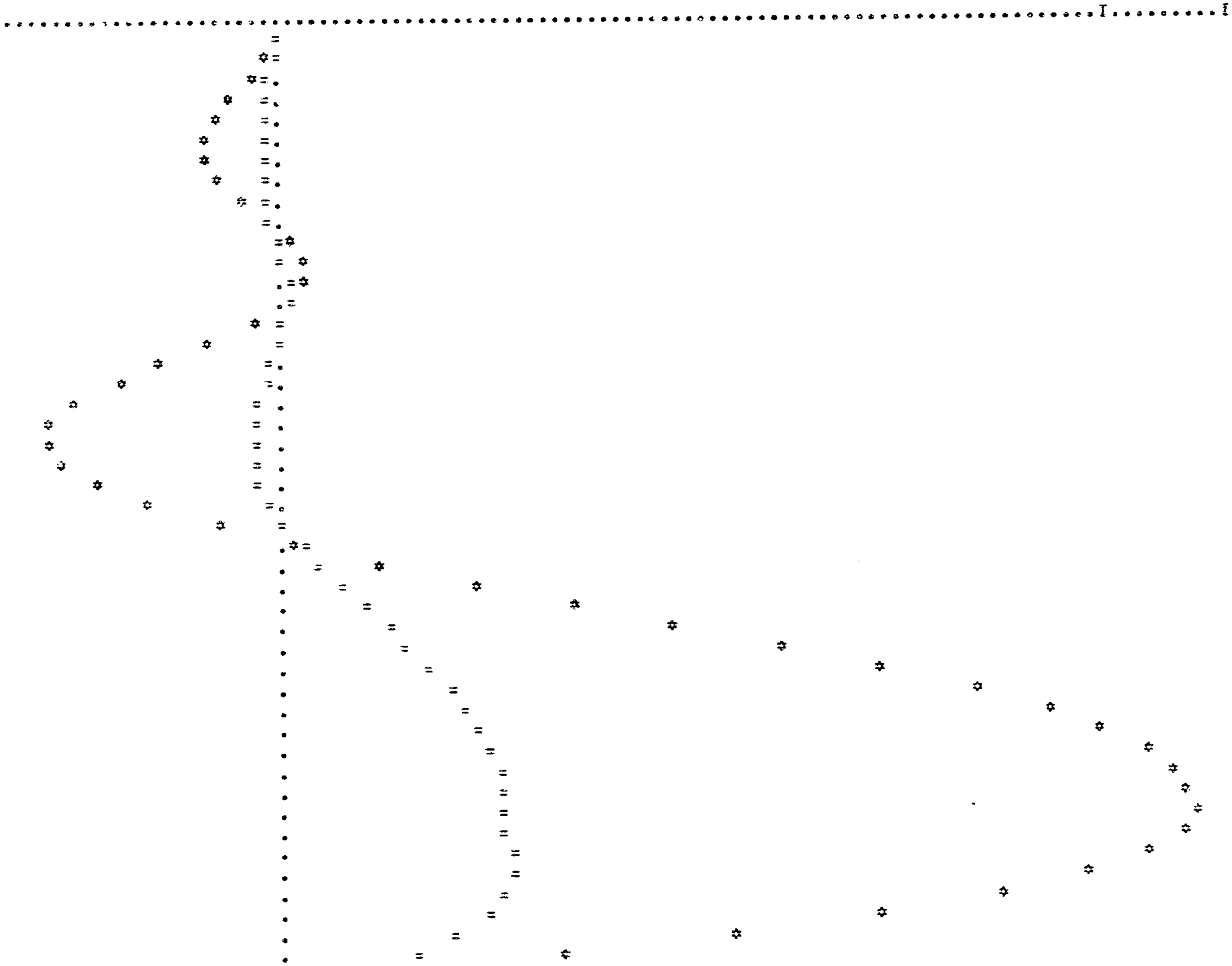
MAXIMUM DRI	HIC
0.0	100.0

BETWEEN 0.1170 AND 0.1800 SEC

AXIAL LOADS IN VERTEBRAL ELEMENTS

TIME (SEC)	LUMBAR (LB) *	NECK (LB) =
0.000	0.00	0.00
0.004	-12.36	-1.59
0.008	-31.32	-5.13
0.012	-52.33	-7.80
0.016	-71.25	-10.71
0.020	-83.76	-14.14
0.024	-82.44	-14.91
0.028	-69.03	-13.60
0.032	-44.64	-10.47
0.036	-13.35	-5.70
0.040	14.84	0.30
0.044	30.62	6.04
0.048	28.92	9.75
0.052	0.86	10.19
0.056	-27.45	7.65
0.060	-76.04	2.47
0.064	-129.94	-5.12
0.068	-181.10	-13.69
0.072	-223.81	-21.35
0.076	-250.16	-26.69
0.080	-256.94	-28.54
0.084	-241.67	-26.14
0.088	-204.23	-19.37
0.092	-146.75	-8.17
0.096	-72.86	6.92
0.100	13.59	25.35
0.104	109.86	46.34
0.108	215.50	69.25
0.112	327.91	93.54
0.116	443.92	118.61
0.120	560.12	143.73
0.124	672.69	168.13
0.128	774.84	190.88
0.132	858.10	210.18
0.136	919.96	224.89
0.140	963.13	235.03
0.144	993.02	241.46
0.148	1014.01	244.89
0.152	1023.12	246.06
0.156	1010.77	250.00
0.160	970.05	256.00
0.164	899.89	258.15
0.168	803.60	252.89
0.172	675.02	231.90
0.176	504.13	193.32
0.180	315.35	146.14

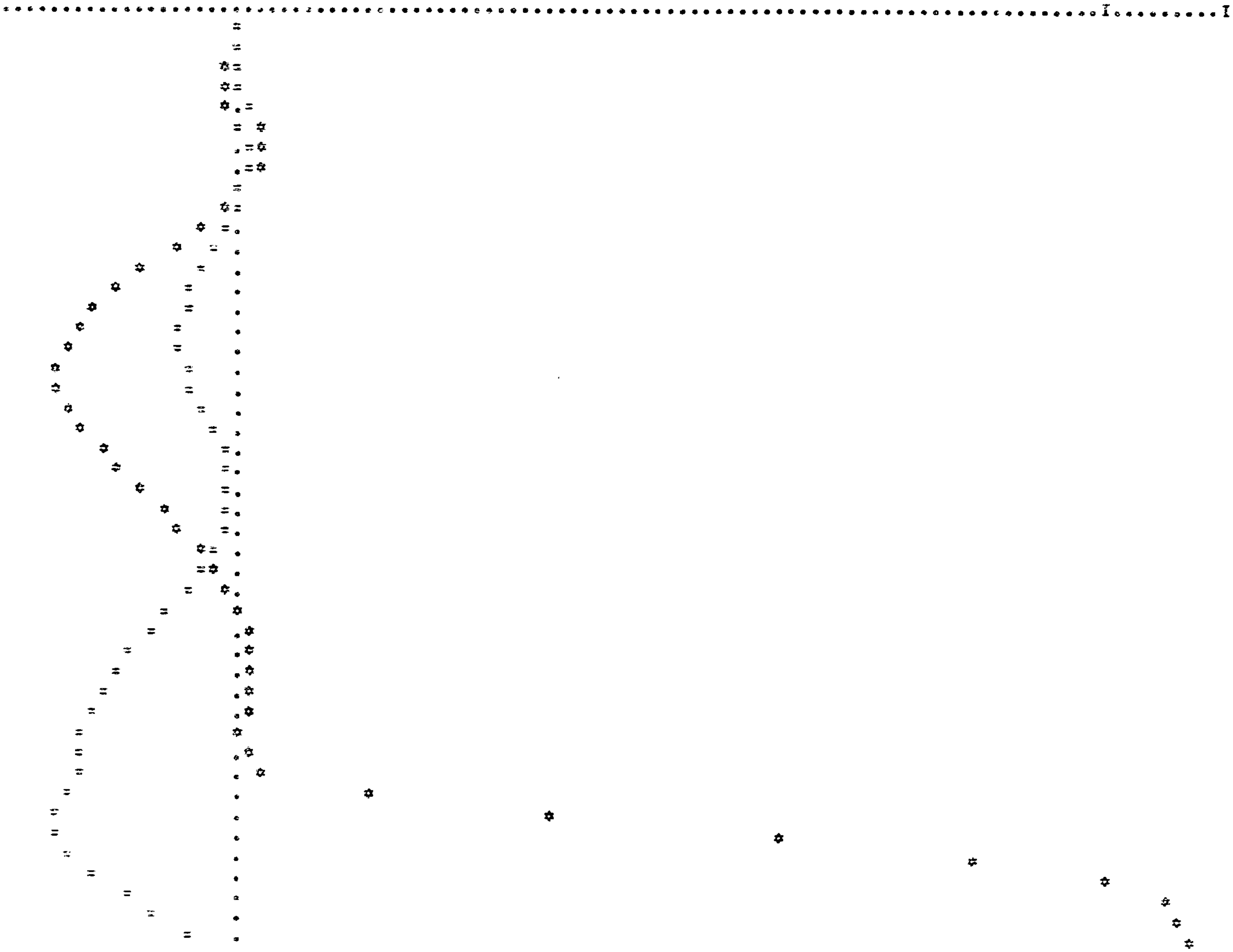
SCALE FACTOR = 0.136E+03



MOMENTS IN VERTEBRAL ELEMENTS

SCALE FACTOR = 0.311E+03

TIME (SEC)	LUMBAR (IN-LB) *	NECK (IN-LB) =
0.000	0.00	0.00
0.004	-27.77	1.33
0.008	-34.84	-2.95
0.012	-42.62	0.33
0.016	-32.66	3.74
0.020	51.32	-2.00
0.024	48.78	3.27
0.028	41.38	3.97
0.032	-0.40	-0.23
0.036	-52.39	-13.28
0.040	-113.64	-35.56
0.044	-182.29	-64.28
0.048	-254.11	-94.87
0.052	-323.53	-122.38
0.056	-380.59	-143.30
0.060	-424.19	-154.55
0.064	-455.30	-154.28
0.068	-469.59	-145.03
0.072	-466.69	-127.24
0.076	-445.27	-103.54
0.080	-408.61	-78.06
0.084	-363.37	-54.37
0.088	-311.84	-37.73
0.092	-258.47	-30.03
0.096	-204.03	-34.90
0.100	-152.69	-51.38
0.104	-106.87	-77.71
0.108	-67.84	-111.89
0.112	-35.78	-151.70
0.116	-10.02	-194.98
0.120	9.92	-239.53
0.124	25.77	-283.24
0.128	29.47	-323.70
0.132	17.07	-360.06
0.136	3.62	-390.55
0.140	-0.13	-412.17
0.144	11.72	-422.80
0.148	64.57	-426.29
0.152	316.49	-444.28
0.156	798.69	-469.70
0.160	1372.56	-478.55
0.164	1872.10	-452.26
0.168	2225.93	-389.67
0.172	2368.20	-304.49
0.176	2399.34	-217.93
0.180	2442.15	-127.56



FORCES APPLIED TO SEAT BY OCCUPANT

TIME (SEC)	SEAT CUSHION (LB) FSC(1)	FSC(2)	FSC(3)	BACK CUSHION (LB) FBC(1)	FBC(2)	FBC(3)	FBC(4)	FBC(5)	FBC(6)	FBC(7)
0.000	135.93	0.00	0.00	17.56	17.56	0.00	0.00	0.00	0.00	0.00
0.004	130.48	0.00	0.00	9.21	2.10	0.00	0.00	0.00	0.00	0.00
0.008	128.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
0.012	130.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.016	137.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.020	149.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.024	173.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.028	207.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.032	252.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.036	308.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.040	371.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.044	437.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.048	503.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.052	567.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.056	627.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.060	679.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.064	724.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.068	759.02	19.32	19.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.072	780.11	31.85	31.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.076	786.34	44.57	44.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.080	775.36	57.41	57.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.084	745.95	69.96	69.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.088	698.48	81.31	81.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.092	634.37	90.91	90.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.096	556.82	98.38	96.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.100	470.37	103.60	103.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.104	380.22	106.69	106.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.108	291.05	107.94	107.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.112	206.63	107.80	107.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.116	129.81	106.85	106.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.120	62.65	105.74	105.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.124	6.16	105.14	105.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.128	0.00	105.18	105.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.132	0.00	105.71	105.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.136	0.00	107.56	107.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.140	0.00	111.77	111.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.144	0.00	119.37	119.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.148	0.00	131.51	131.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.152	0.00	151.85	151.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.156	0.00	184.73	184.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.160	0.00	232.00	232.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.164	0.00	293.29	293.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.168	0.00	366.27	366.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.172	185.45	442.41	442.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.176	241.92	510.64	510.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.180	273.18	567.35	567.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00

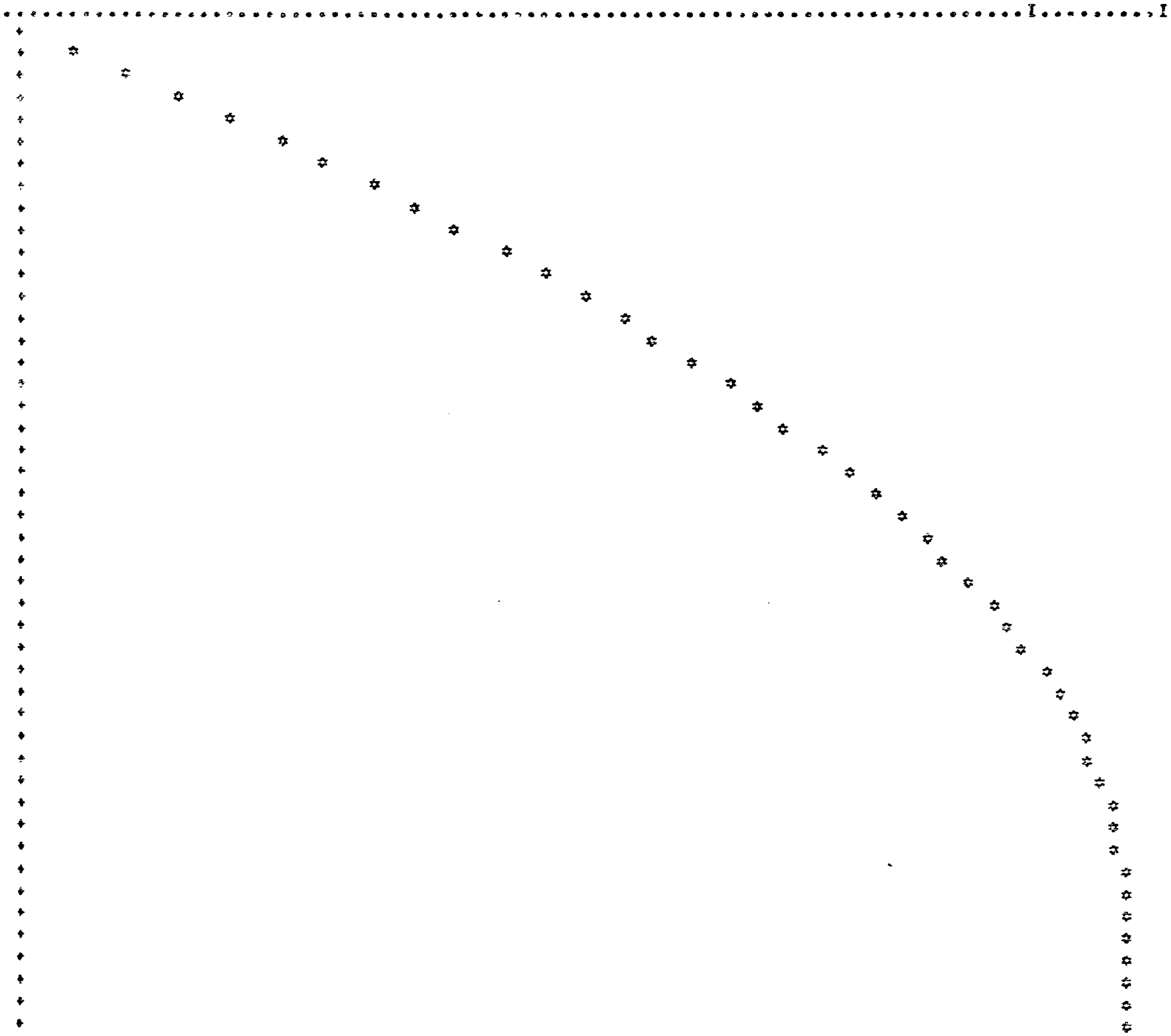
FORCES BETWEEN FEET AND FLOOR

TIME	RIGHT			LEFT		
(SEC)	X	Y	Z	X	Y	Z
0.000	0.00	0.00	0.00	0.00	0.00	0.00
0.004	0.00	0.00	6.52	0.00	0.00	6.52
0.008	-2.14	0.00	16.84	-2.14	0.00	16.84
0.012	-6.66	0.00	26.73	-6.66	0.00	26.73
0.016	-8.76	0.00	35.07	-8.76	0.00	35.07
0.020	-10.43	0.00	41.75	-10.43	0.00	41.75
0.024	-12.40	0.00	49.62	-12.40	0.00	49.62
0.028	-13.31	0.00	53.24	-13.31	0.00	53.24
0.032	-12.26	0.00	49.05	-12.26	0.00	49.05
0.036	-9.47	0.00	37.87	-9.47	0.00	37.87
0.040	-7.23	0.00	28.93	-7.23	0.00	28.93
0.044	-8.20	0.00	32.78	-8.20	0.00	32.78
0.048	-11.94	0.00	47.76	-11.94	0.00	47.76
0.052	-15.47	0.00	61.88	-15.47	0.00	61.88
0.056	-15.86	0.00	63.45	-15.86	0.00	63.45
0.060	-11.17	0.00	44.71	-11.17	0.00	44.71
0.064	-3.74	0.00	14.97	-3.74	0.00	14.97
0.068	0.00	0.00	0.00	0.00	0.00	0.00
0.072	0.00	0.00	0.00	0.00	0.00	0.00
0.076	0.00	0.00	0.00	0.00	0.00	0.00
0.080	0.00	0.00	0.00	0.00	0.00	0.00
0.084	0.00	0.00	0.00	0.00	0.00	0.00
0.088	0.00	0.00	0.00	0.00	0.00	0.00
0.092	0.00	0.00	0.00	0.00	0.00	0.00
0.096	0.00	0.00	0.00	0.00	0.00	0.00
0.100	0.00	0.00	0.00	0.00	0.00	0.00
0.104	0.00	0.00	0.00	0.00	0.00	0.00
0.108	0.00	0.00	0.00	0.00	0.00	0.00
0.112	0.00	0.00	0.00	0.00	0.00	0.00
0.116	0.00	0.00	0.00	0.00	0.00	0.00
0.120	0.00	0.00	0.00	0.00	0.00	0.00
0.124	0.00	0.00	0.00	0.00	0.00	0.00
0.128	0.00	0.00	0.00	0.00	0.00	0.00
0.132	0.00	0.00	0.00	0.00	0.00	0.00
0.136	0.00	0.00	0.00	0.00	0.00	0.00
0.140	0.00	0.00	0.00	0.00	0.00	0.00
0.144	0.00	0.00	0.00	0.00	0.00	0.00
0.148	0.00	0.00	0.00	0.00	0.00	0.00
0.152	0.00	0.00	0.00	0.00	0.00	0.00
0.156	0.00	0.00	0.00	0.00	0.00	0.00
0.160	0.00	0.00	0.00	0.00	0.00	0.00
0.164	0.00	0.00	0.00	0.00	0.00	0.00
0.168	0.00	0.00	0.00	0.00	0.00	0.00
0.172	0.00	0.00	0.00	0.00	0.00	0.00
0.176	0.00	0.00	0.00	0.00	0.00	0.00
0.180	0.00	0.00	0.00	0.00	0.00	0.00

AIRCRAFT DISPLACEMENT

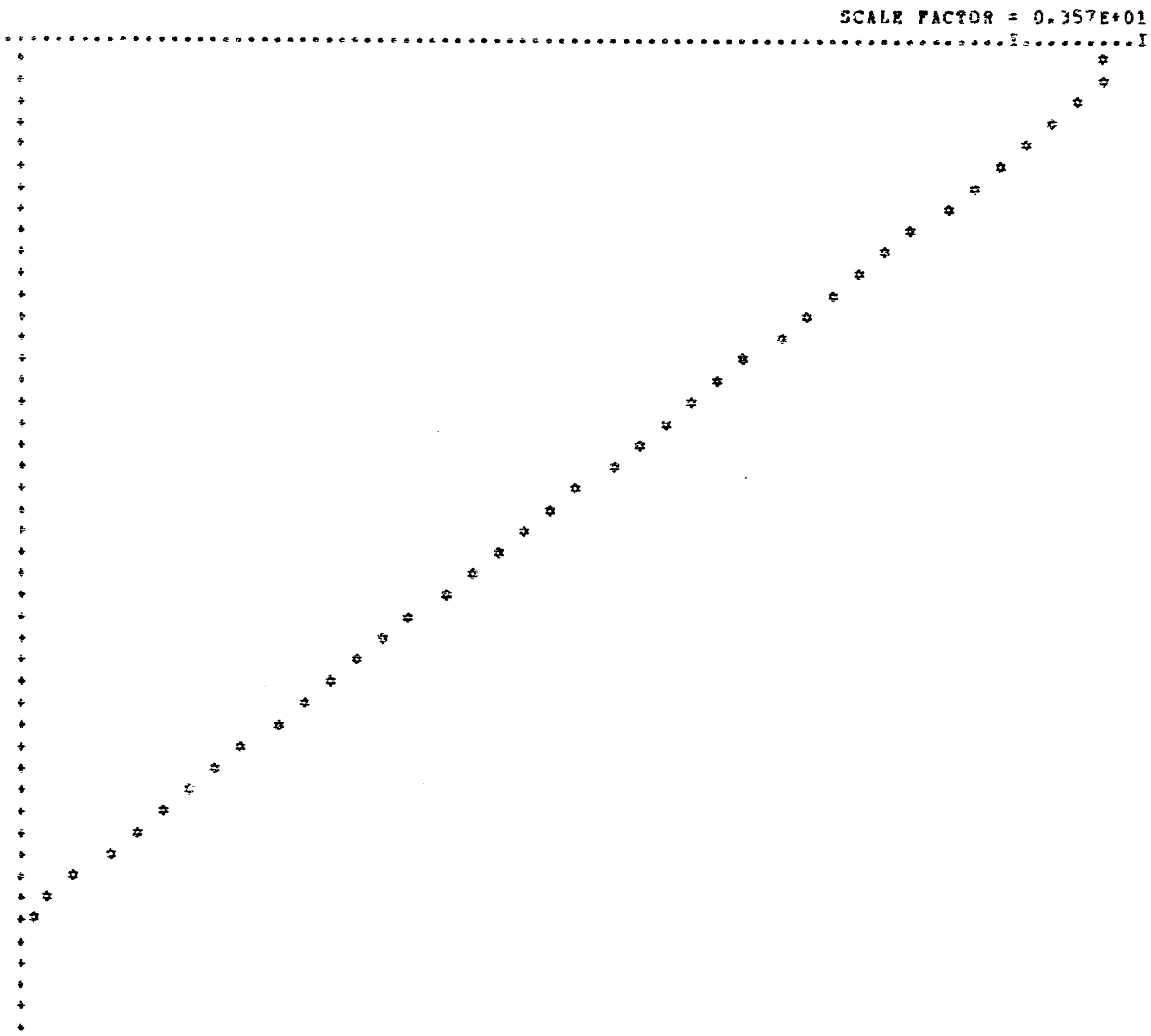
TIME (SEC)	X (IN) *	Y (IN) =	Z (IN) +
0.000	0.00	0.00	0.00
0.004	1.44	0.00	0.00
0.008	2.86	0.00	0.00
0.012	4.25	0.00	0.00
0.016	5.61	0.00	0.00
0.020	6.93	0.00	0.00
0.024	8.21	0.00	0.00
0.028	9.46	0.00	0.00
0.032	10.67	0.00	0.00
0.036	11.84	0.00	0.00
0.040	12.97	0.00	0.00
0.044	14.07	0.00	0.00
0.048	15.13	0.00	0.00
0.052	16.15	0.00	0.00
0.056	17.13	0.00	0.00
0.060	18.08	0.00	0.00
0.064	18.99	0.00	0.00
0.068	19.87	0.00	0.00
0.072	20.71	0.00	0.00
0.076	21.51	0.00	0.00
0.080	22.27	0.00	0.00
0.084	22.99	0.00	0.00
0.088	23.68	0.00	0.00
0.092	24.33	0.00	0.00
0.096	24.95	0.00	0.00
0.100	25.53	0.00	0.00
0.104	26.07	0.00	0.00
0.108	26.57	0.00	0.00
0.112	27.04	0.00	0.00
0.116	27.47	0.00	0.00
0.120	27.86	0.00	0.00
0.124	28.21	0.00	0.00
0.128	28.53	0.00	0.00
0.132	28.81	0.00	0.00
0.136	29.05	0.00	0.00
0.140	29.26	0.00	0.00
0.144	29.43	0.00	0.00
0.148	29.56	0.00	0.00
0.152	29.66	0.00	0.00
0.156	29.72	0.00	0.00
0.160	29.74	0.00	0.00
0.164	29.75	0.00	0.00
0.168	29.75	0.00	0.00
0.172	29.75	0.00	0.00
0.176	29.76	0.00	0.00
0.180	29.76	0.00	0.00

SCALE FACTOR = 0.354E+01



AIRCRAFT VELOCITY

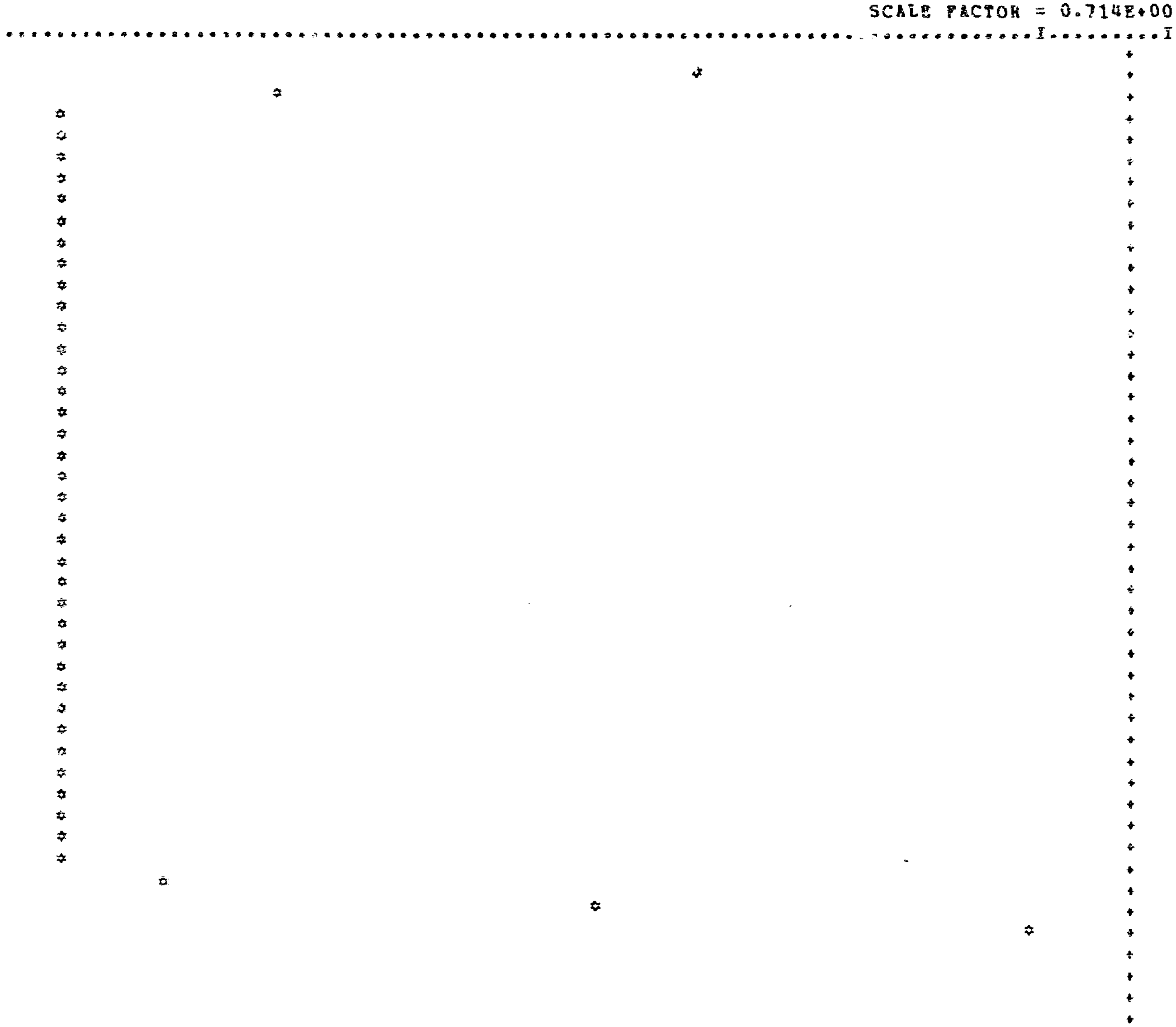
TIME (SEC)	X (FPS) *	Y (FPS) =	Z (FPS) +
0.000	30.00	0.00	0.00
0.004	29.65	0.00	0.00
0.008	29.38	0.00	0.00
0.012	28.65	0.00	0.00
0.016	27.87	0.00	0.00
0.020	27.10	0.00	0.00
0.024	26.33	0.00	0.00
0.028	25.56	0.00	0.00
0.032	24.78	0.00	0.00
0.036	24.01	0.00	0.00
0.040	23.24	0.00	0.00
0.044	22.46	0.00	0.00
0.048	21.69	0.00	0.00
0.052	20.92	0.00	0.00
0.056	20.15	0.00	0.00
0.060	19.37	0.00	0.00
0.064	18.60	0.00	0.00
0.068	17.83	0.00	0.00
0.072	17.05	0.00	0.00
0.076	16.28	0.00	0.00
0.080	15.51	0.00	0.00
0.084	14.74	0.00	0.00
0.088	13.96	0.00	0.00
0.092	13.19	0.00	0.00
0.096	12.42	0.00	0.00
0.100	11.64	0.00	0.00
0.104	10.87	0.00	0.00
0.108	10.10	0.00	0.00
0.112	9.33	0.00	0.00
0.116	8.55	0.00	0.00
0.120	7.78	0.00	0.00
0.124	7.01	0.00	0.00
0.128	6.23	0.00	0.00
0.132	5.46	0.00	0.00
0.136	4.69	0.00	0.00
0.140	3.92	0.00	0.00
0.144	3.14	0.00	0.00
0.148	2.37	0.00	0.00
0.152	1.60	0.00	0.00
0.156	0.83	0.00	0.00
0.160	0.29	0.00	0.00
0.164	0.06	0.00	0.00
0.168	0.03	0.00	0.00
0.172	0.05	0.00	0.00
0.176	0.05	0.00	0.00
0.180	0.05	0.00	0.00



AIRCRAFT ACCELERATION

SCALE FACTOR = 0.714E+00

TIME (SEC)	X (G) *	Y (G) =	Z (G) +
0.000	0.00	0.00	0.00
0.004	-2.40	0.00	0.00
0.008	-4.80	0.00	0.00
0.012	-6.00	0.00	0.00
0.016	-6.00	0.00	0.00
0.020	-6.00	0.00	0.00
0.024	-6.00	0.00	0.00
0.028	-6.00	0.00	0.00
0.032	-6.00	0.00	0.00
0.036	-6.00	0.00	0.00
0.040	-6.00	0.00	0.00
0.044	-6.00	0.00	0.00
0.048	-6.00	0.00	0.00
0.052	-6.00	0.00	0.00
0.056	-6.00	0.00	0.00
0.060	-6.00	0.00	0.00
0.064	-6.00	0.00	0.00
0.068	-6.00	0.00	0.00
0.072	-6.00	0.00	0.00
0.076	-6.00	0.00	0.00
0.080	-6.00	0.00	0.00
0.084	-6.00	0.00	0.00
0.088	-6.00	0.00	0.00
0.092	-6.00	0.00	0.00
0.096	-6.00	0.00	0.00
0.100	-6.00	0.00	0.00
0.104	-6.00	0.00	0.00
0.108	-6.00	0.00	0.00
0.112	-6.00	0.00	0.00
0.116	-6.00	0.00	0.00
0.120	-6.00	0.00	0.00
0.124	-6.00	0.00	0.00
0.128	-6.00	0.00	0.00
0.132	-6.00	0.00	0.00
0.136	-6.00	0.00	0.00
0.140	-6.00	0.00	0.00
0.144	-6.00	0.00	0.00
0.148	-5.00	0.00	0.00
0.152	-6.00	0.00	0.00
0.156	-5.40	0.00	0.00
0.160	-3.00	0.00	0.00
0.164	-0.60	0.00	0.00
0.168	0.00	0.00	0.00
0.172	0.00	0.00	0.00
0.176	0.00	0.00	0.00
0.180	0.00	0.00	0.00



FINAL GENERALIZED COORDINATES

J	Q(J)	QD(J)	QDD(J)
1	0.5017E+02	0.7902E+00	-0.8574E+03
2	0.2105E+02	-0.5555E+02	0.1696E+04
3	0.9325E+00	0.2317E+01	0.1073E+03
4	0.1143E+02	-0.3609E+02	-0.2017E+04
5	0.1103E+01	0.1277E+02	-0.2693E+02
6	0.6558E+01	-0.7137E+01	-0.7674E+03
7	0.1433E+01	0.1583E+02	0.1234E+03
8	0.8095E-01	-0.7870E+01	-0.8139E+02
9	0.3606E+00	-0.8067E+01	0.3383E+02
10	0.2302E+00	0.5368E+00	0.1510E+03
11	-0.9255E+00	-0.6991E+01	0.1595E+03

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